Alfred Irfan Frashëri, u lind më 20.4.1935.në Korçë. U diplomua Inxhinier Gjeolog i specializuar në gjeofizikë, në Universitetin e Tiranës (1961). Një ndër specialistët e parë të gjeofizikës, që ka kontribuar në ngritjen, organizimin dhe zhvillimin e Gjeofizikës Shqiptare, në veçanti të përgatitjes së specialistëve gjeofizikë. Kandidat i shkencave (1974), docent (1982), doktor i shkencave (1987), profesor (1989) dhe "Nder i Akademisë së Shkencave e Shqipërisë (2015). Pedagog në Universitetin e Tiranës dhe atë Politeknik për 46 vjet për lëndët e specialitetit gjeofizik. Ka botuar 11 tekste mësimore. Ka mbajtur i ftuar leksione dhe në disa Universitete evropiane, në U.S.A. dhe në Kanada. Ka udhehequr 8 disertantë. Ka eksperimentuar dhe zbatuar për herë të parë në Shqipëri metodat e reja gjeofizike, ka kontribuar në zgjerimin e fushave të zbatimit gjeofizikës, është një ndër nismetarët e kërkimeve gjeofizike të naftës dhe të gazit në detin Adriatik, të informatizimit gjeofizikës, të studimit të burimeve të energjisë gjeotermale. Ka kryer 73 studime dhe ka drejtuar 28 projekte, nga të cilët 5 ndërkombëtarë. Ka botuar 12 monografi, 22 libra, 62 artikuj në periodikun shkencor shqiptar dhe 22 në periodikun shkencor ndërkombetar, ka referuar në 78 në kongrese e konferenca shkencore kombetare dhe në 157 ndërkombëtare, si edhe 71 artikuj problemorë në gazetat shqiptare. Po jep një kontribut të çmuar për historikun e Frashërit si edhe për probleme ekonomike të Përmetit.Ka botuar e ribotuar librin "Frashëri në historinë e Shqipërisë (2007).

Komuna Frashër i ka akorduar titullin ,Nder i Frashërit―(2011). Me propozim të Shoqatës AK Përmeti është dekoruar me Urdhërin „Mjeshtër i Madh" (2012). Mban edhe Urdhërin Naim Frashëri të klasit III (1977), medaljen e Punës (1955), si edhe me Medal of Honor Millenium 2000 nga American Biographical Institute. Është anëtar Nderi i Bashkimit Europian të Gjeoshkencëtarëve dhe Inxhinierëve (EAGE) dhe i Shoqatës Gjeofizike të Ballkanit, anëtar i Shoqatës së Gjeofizikantëve Kërkues të USA (SEG), i Shoqatës Ndërkombëtare të Gjeotermisë (IGA) dhe akademik i Institutit te Athinës për Edukim dhe Kërkim (AIER). Është një nga nismëtarët e krijimit të Shoqatës Gjeofizike të Shqipërisë dhe i Bashkimit Shqiptar të Gjeoshkencëtarëve dhe Inxhinjerëve, të cilat i ka drejtuar për shumë vjet. Është anëtar Nderi i Shoqatës Atdhetare Kulturore Mbarëkombëtare Përmeti, si edhe i Shoqatës Atdhetare Kulturore Mbarëkombëtare "Vellezerit Frasheri".

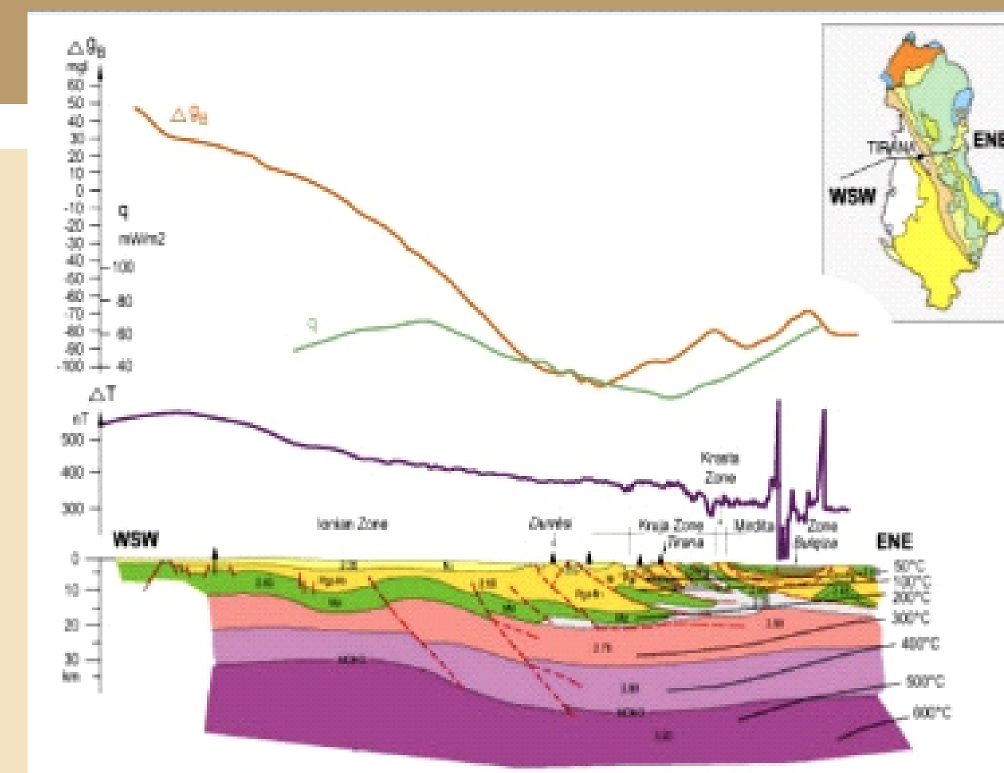
Alfred FRASHËRI

NJË JETË "NDRIÇUAM" NËNTOKËN E ATDHEUT PËR TË KËRKUAR MINERALET

VOL 1-3

Alfred FRASHËRI

NJË JETË "NDRIÇUAM" NËNTOKËN E ATDHEUT PËR TË KËRKUAR MINERALET



THROUGHPUT LIFE WE HAVE ENLIGHTENED HOMELAND UNDERGROUND FOR MINERALS EXPLORATION

Patos, 5 shtator 1953 - Tiranë 6 prill 2016

Alfred FRASHËRI

NJË JETË "NDRIÇUAM" NËNTOKËN E ATDHEUT PËR TË KËRKUAR MINERALET

Volumi 1

THROUGHPUT LIFE WE HAVE ENLIGHTENED HOMELAND UNDERGROUND FOR MINERALS EXPLORATION

Patos, 5 shtator 1953 - Tiranë 6 prill 2016

Në këtë liber janë përrzgjedhur 85 artikuj të botuar ose referuar nga 62 artikuj, të botuar nga A. Frashëri me 32 bashkautorë, në periodikun shkencor shqiptar dhe 22 në atë ndërkombëtar, si edhe të 78 kumtesave të mbajtur në konferenca e kongrese shkencore kombëtare dhe 157 ndërkombëtare, jashtë shtetit ose në Tiranë.

Editor: Alfred Frashëri

Bashkautorët e studimeve: Alfred Frashëri,

Kërkime gjeofizike: Ligor Lubonja, Pertef Nishani, Përparim Alikaj, Radium Avxhiu, Rushan Liço, Salvatore Bushati, Vilson Bare,

Informatizim i Gjeofizikës: Neki Frashëri, Gudar Beqiraj, Ylli Vejsiu, Betim Çiço,

Gjeofizikë inxhinierike dhe e mjedisit: Eduard Sulstarova, Niko Pano, Ludvig Kapllani, Foto Dhima, Burhan Çanga, Hajri Haska, Bardhy Avdyli, Etrit Taushani, Fatos Hoxhaj, Marenglen Gjonaj, Rexhep Koci,

Energjia gjeotermale: , Fiqiri Bakalli, Andonaq Londo, Anesti Qirinxhi, Angjelin Shtjefni, Atifete Zuna. Bashkim Çela, Entel Xinxo, Nevton Kodhelaj, Ramadal Alushaj, Romeo Eftimi, Spiro Thodhorjani.

Pëgatitur për botim: Alfred Frashëri:

Përpunimi i imazheve satelitore: Neki Frashëri

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Këtë liber ja përkushtoj:

Prindërve të mij, Irfanit dhe Zejnepes, gruas Marika dhe fëmijëve Ermalit dhe Editës, që më edukuan, më mësuan si duhet të rroj dhe punoj, më krijuan të gjitha kushtet dhe lehtësitë, që ti perkushtohem studimeve dhe kërkimeve gjeofizike 63 vjeçare!

Me shumë respekt ja ***përkushtoj*** *librin Shkollës fillore "Naim Frashëri" në Korçë, që më mësoj abc-në dhe më mëkoi me dashurinë për Shqipërinë, Shkollën e madhe të punës dhe rinisë "Politeknikumin 7 Nëntori", që krahas profesionit na kaliti edhe vrullin rinor për të bërë punëra të mira, Fakultetin e Gjeologjisë dhe të Minierave të Universitetit Politeknik të Tiranës, që na hapi dyert e dijes së shkencave të Tokës, ka i mësoi ato, na kualifikoj dhe na bëri të aftë të realizojmë kërkimet shkencore që kërkonte ekonomia e vendit!*

Librin, me shumë respekt e dashuri, ja ***përkushtoi*** *edhe 33 bashkautorëve të 82 artikujve të përzgjedhur për këtë libër. Ne realizuam detyrat tona se kishim kuptuar dhe vënë në jetë një porosi të kohës: kërkimi shkencor, aq më tepër ai gjeologjik, kryhet me ekipe komplekse. Brezit tonë, të gjysmës së dytë të shekullit të XX-të, i ra detyra e madhe të kërkonim, të zbulonim pasuritë minerale që me aqë bujari na i ka falur natyra mëmë dhe ti vinim në shfrutëzim të ekonomisë kombëtare. Për realizimin e kësaj detyre madhore, në ballë të zhvillimit ekonomik të vendit, na u krijuan edhe kushtet tekniko-shkencore komplese të kohës. Me përkushtim, me devotshmëri dhe me sakrifica, brezi i ynë i realizoi me nder detyrat. Naftëtarët, minatorët, teknikët, ingjinierët, shkencëtarët e industrive të naftës e gazit, të industrisë minerare të bakrit, kromit, qymyreve etj. zbuluan vendburimet dhe i dhanë ekonomisë së vendit rezerva të mëdha, të cilat lejuan të arrihet një prodhim vjetor ndër vendet e para për numur të banorëve.*

Mjafton të përmendim se në vitin 1984 u nxorrën 1,007,000 ton minerale bakri dhe u përpunuan 12,600 ton baker blister, si edhe 960,000 ton kromite. Të ardhurat mesatare nga industria nxjerrëse e bakrit dhe e kromit arrtën 120 milion USD/vit. Rreth 20 milion ton mineral bakri dhe 21 milion ton kromite ka nxjerrë Insustria Minerare Shqiptare. Prodhimi i naftës arriti pikun me 2.250.000 ton në vitin 1973. Deri në vitin 1990, janë nxjerrë 49, 5 milion ton naftë, rreth 12 milion metër kub gas natyral dhe 47 milion ton

qymyr guri. Përmenda nxjerrje e vitit 1984, sepse për fat të keq, në periudhën e tranzicionit pas vitit 1990 është zvogëluar në mënyrë drastike nxjerrja e naftës, e gazit dhe e mineraleve të dobishme të ngurta. Sipas të dhënave zyrtare të INSTAT, zvogëlimi i prodhimit të indutrisë minerare është si më poshtë vijon: 88.6 në 1994, 86.5 në 1995, 75.8 në 1996, 47.1 në 1997, 74.5 në 1998, 35.5 në 1999, 31.0 në 2000, dhe 27.0 në 2001.

Kërkimet gjeologjike kanë vlerësuar se burimet minerale janë të afta të nxjerrin 31 milion ton naftë, 53 milion ton minerale bakri, 40 milion ton kromite, 220 milion ton hekur-nikel, 100 milion ton nikel, 700 milion ton qymyre. Më shumë se dyfishi i xeherorëve të nxjerrë të bakrit dhe kromit, kërkimi gjeologjik i ka vlerësuar si burime për të ardhmen.

Të gjithë brezat e gjeofizikanëve, nga më të vjetërit e deri tek ata që janë diplomuar vitet e fundit, me pasion, këmbëngulje, vullnet e disiplinë, realizuan detyrat e tyre, zhvilluan gjeofizikën shqiptare, dhanë kontribut të shquar në kuadrin e kërkimeve komplekse gjeologjike-gjeofizike-gjeokimike të vendburimeve të naftës dhe të gazit (Marinzë, Arrëz, Kallm-Verri, Cakran, Mollaj, Amonicë, Divjakë, Frakull, Povelçë, Durrës-shelf, etj.), të shumë vendburimeve të bakrit (Gjegjan, Tuçi lindor, Kaçinar, Qafë Bari, Palucë, Lak Roshi, Munellë, Golaj-Nikoliq, Palaj-Karmë, Perlat, Rehovë, etj.). Vetëm gjatë vitit 1989 janë projektuar 356 shpime për verifikimin e anomalive gjeofizike në 35 objekte, nga të cilët 145 zbuluan mineralizimin e kromit. Studimet gjeofizike krahinore: gravimetrike, magnetometrike, gjeotermale kontribuan në studimin e gjeologjisë së Albanideve dhe e bënë atë të njohur tej kufinjve të vendit. Janë botuar dhjetra monografi, 637 artikuj në periodikun shkencor shqiptar dhe 33 në atë ndërkombëtar dhe qindra të tjerë të referuar me sukses nga gjeofizikanët shqiptarë, në forume shkencore madhore ndërkombëtare, duke u renditur midis ambasadorëve më të mirë shqiptarë në komunitetin ndërkombëtar.

Krahas zhvillimit dhe rritjes së industrive të naftës e gazit, si edhe asaj minerare, u formuan edhe kuadrot e nevojme pranë Fakultetit të Gjeologjisë dhe të Minerave. Nga **dega e gjeofizikës** u përgatitën 304 inxhinierë gjeofizikë, midis të cillëve 7 profesorë, 45 doktorë shkencash, 1 asistent profesor, 9 drejtues kërkimi dhe 12 mjeshtra kërkimi. Për fat të keq, kjo degë vitet e fundit është mbyllur. Është injoruar fakti se pa gjeofizikë, kërkimet gjeologjike kthehen në nivelin e shekullit te 19-të, kthehen si mjekët pa radioskopi e radiografi, pa skanera, vetëm me stetoskopin e shekujve të kaluar. Janë mbyllur edhe tre ndërmarrjet e spcializuara tv gjeofixikës, për kërkimin e naftë dhe të gazit, për studimin e puseve të thellë të naftës e

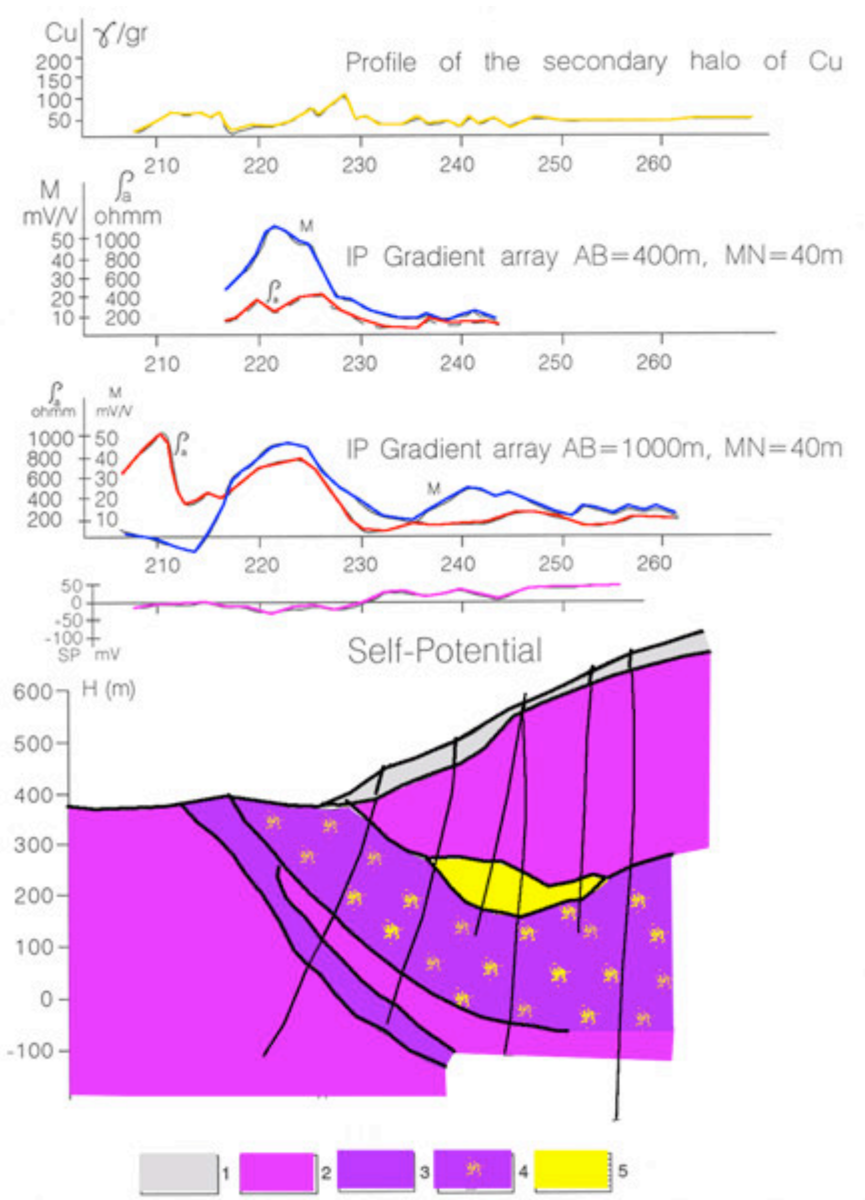
gazit, si edhe për kërkimin e mineraleve të dobishme të ngurta - bakrit, kromit, etj.

Falenderime:

Përzemërsisht i shpeh mirënjohjen time të thellë dhe falenderimet më të mira bashkautorëve, me të cilët realizuam kërkimin shkencor, bëmë interpretimin e të dhënave të vrojtimeve në terren dhe në laborator, si edhe shkruam artikujt që jane vendosur në liber. Ka qenë një punë e përbashkët, me mirëkuptim dhe respekt shoqëror, e cila solli një product skencor me vlerë për vendin dhe tv mirënjohur .

Falenderoj dhe shpreh respektin tim për drejtuesit ndër vite të Fakultetit të Gjeologjisë dhe të Minierave, të Kryesisë së Akademisë së Shkencave dhe Seksionit të Shkencave Teknike dhe të Natyrës së Akademisë, të Qendrës së Kërkimeve Gjeofizike, Gjeokimike dhe të Mjedisit, Tiranë, të Ndërmarrjes Sizmo-Gravimetrie në Fier dhe të Gjeofizikës Kantierale në Patos, për krijimin e kushteve sa më të mira dhe të përshtatshme për realizimin e studimeve të ndërmarra bashkarisht.

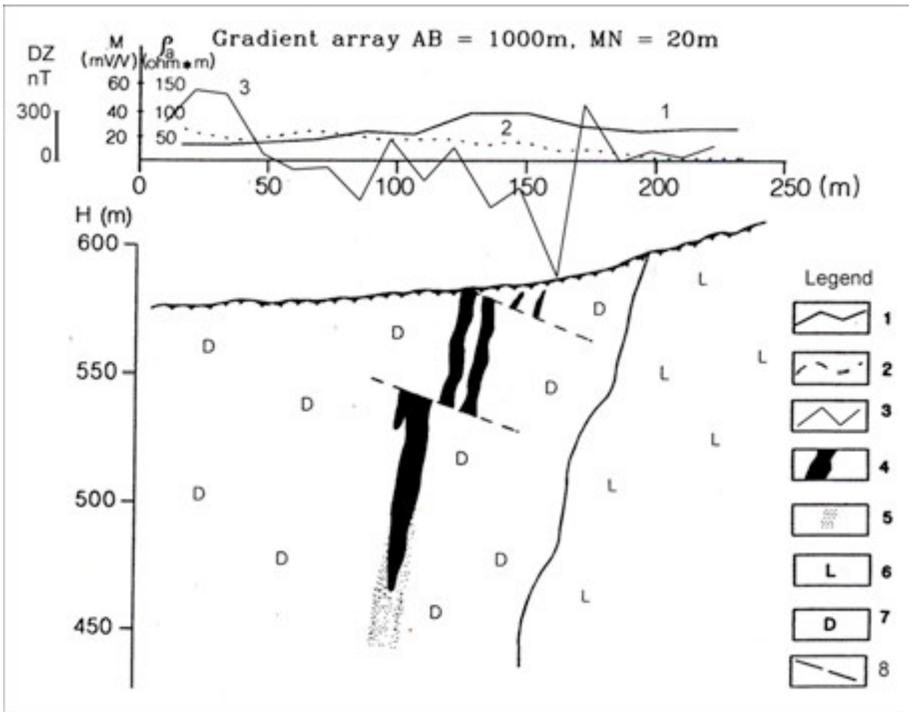
Me veneracion kujtoj kolegët bashkautorë, shokët që nuk janë më me ne, profesorin tim Ligor Lubonja dhe mandej bashkëpunëtorin për tridhjetë vjet, për dijet që më dha, punën kërkimore të përbashkët dhe respektin reciprok. Kujtoj studimet e përbashkëta me Radium Avxhiun, studentin që me aqë pasion punoi për kërkimin e bakrit në Pukë dhe Mirditë, laurantin e Çmimit të Republikës për zbulimin e vendburimit të Qafë Barit. Midis tyre është edhe Akademiku Eduard Sulstarova, si edhe Pertef Nishani. që me aqë përkushtim realizonin bashkëpunimin në kërkimin shkencor dhe formimin e inxhinierëve gjeofizikë.



Prerje gjeologo-gjeofizie në vendburimin e Qafës së Barit, Pukë.

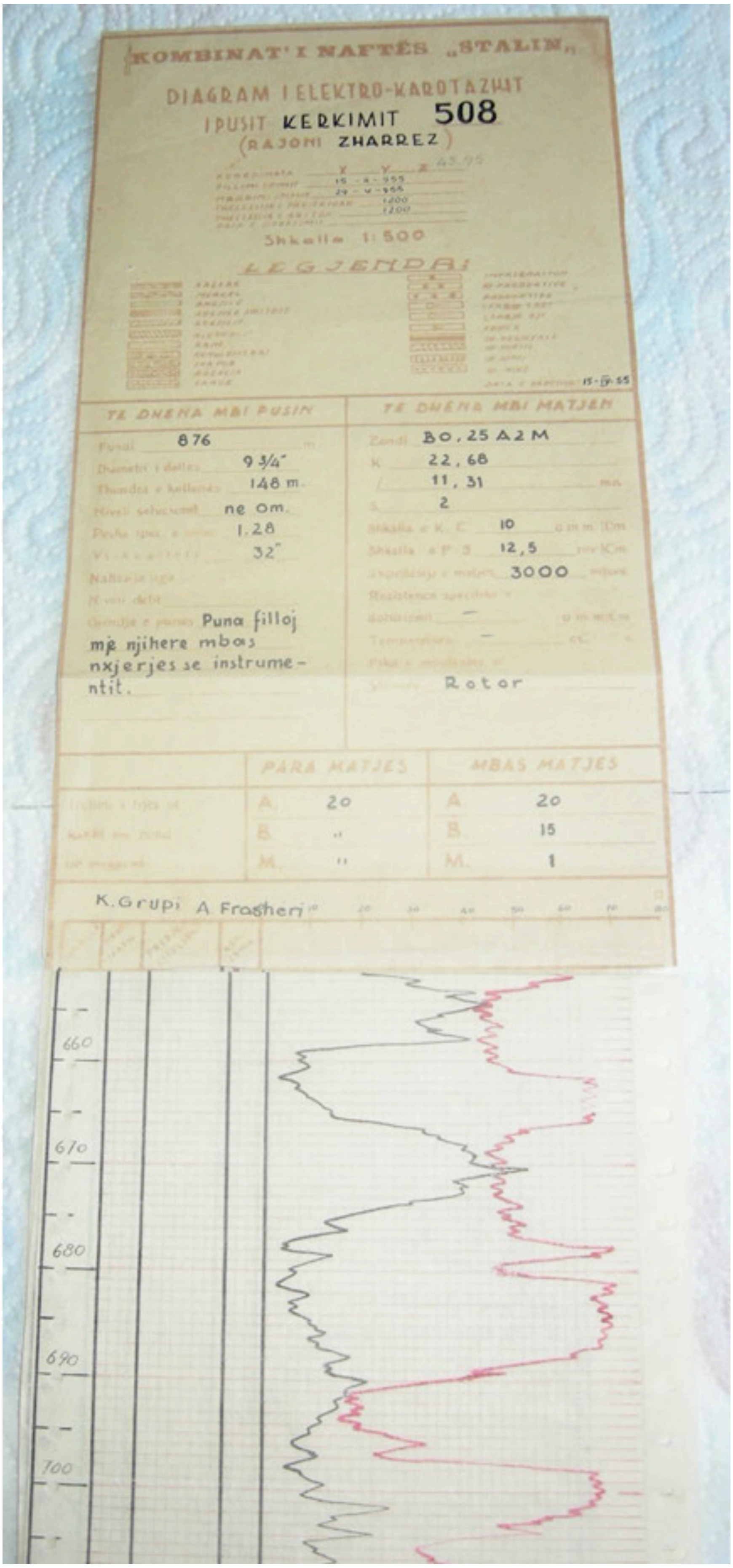
(Sipas rilevimeve të Alfred Frashëri A (1961) dhe Radium Avxhiu (1972-1973.

1- Deluvione; 2- Keratofirë; 3- Spilite; 4- Sulfide të shpërndara sulphides; 5- Trup xeheror massif sulfuresh.



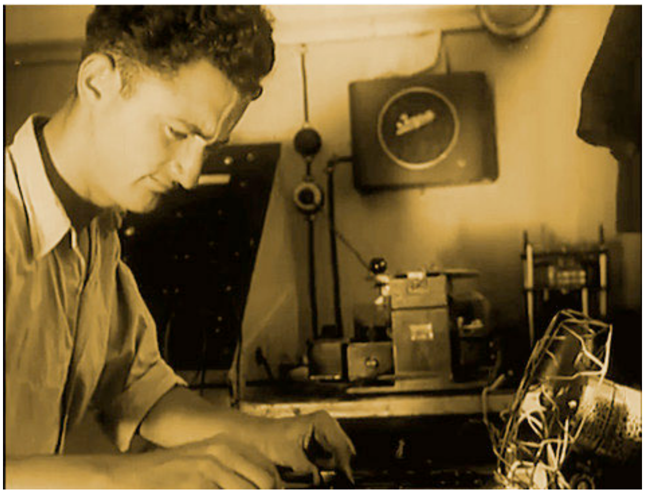
Prerje gjeologo-gjeofizie në vendburimin e kromiteve në Vlahnë

Me rezultatet e eksperimenteve të para të metodës së potencialeve të polarizimit të provokuar për kërkimin e kromit (Frashëri A., Lubonja L., 1962)



Diagramet e karotazhit në pusin Zharës 508, 15 prill 1955, regjistruar nga operatori Alfred Frashëri.
Diagrami me ngjyrë të zezë- rezistenca elektrike specifike e shtresave, me ngjyrë të kuqe- potenciali i polarizimit elektrik spontan

Ekipi i karotazhit, Patos 1955.



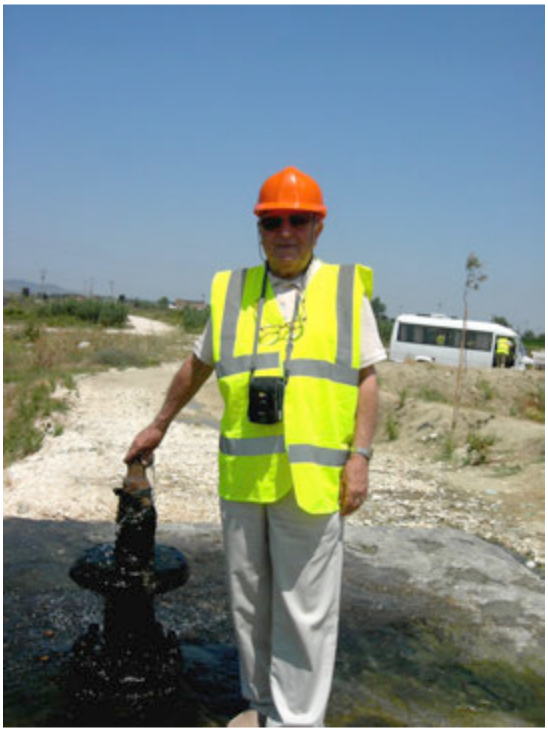
Operatori karotazhit Hamdi Bejtja

Gjeologu Adem Cani

Ingjinier gjeolog Tomi Kristo, Fier 1974

Teknikët Hamdi Bejtja, Tomi Kristo, Alfred Frashëri, Pator 1955

Patosi i sipërm, 3 prill 2016



Alfred Frashëri
Në pusin Marinë 542, pas 58 vjetëve nga dita kur regjistroi diagramin paraprak tv karotazhit.

Pas gjysëm shekulli, Teknikët e vjetër, sot ingjinierë, që punuan për shpimin, studimin dhe nxjerrjen e naftës nga pusi Marinzë 542 që fontanoi në vitin 1957, u ftuan nga kompania e naftës Bankers për të vizituar Marinzën dhe Pusin e mirënjohur.

Fontana e pusit
Marinze 542

Një leksion i hapur i Prof. Dr. Alfred Frashërit në Fakultetin e Gjeologjisë dhe të Minierave, 2008, si edhe student të degës së gjeofizikës në praktikën në terren.

Katedra e Gjeofizikës, Fakulteti i Gjeologjisë dhe i Minierae, në vitet 70-të
Nga e majta në të djathtë: Rushan Liço, Pertef Nishani, Ligor Lubonja (Përgjegjvsi i Katedrës, Alfred Frashëri.

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b) Pano N., Frashëri, Avdyli B., Hoxhaj F., 2014. Outlook on Seawaters Dynamics Factors for the Albanian Adriatic Coastline Developments

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XII International IAEG Congress, Torino, September 15th – 19th, 2014.
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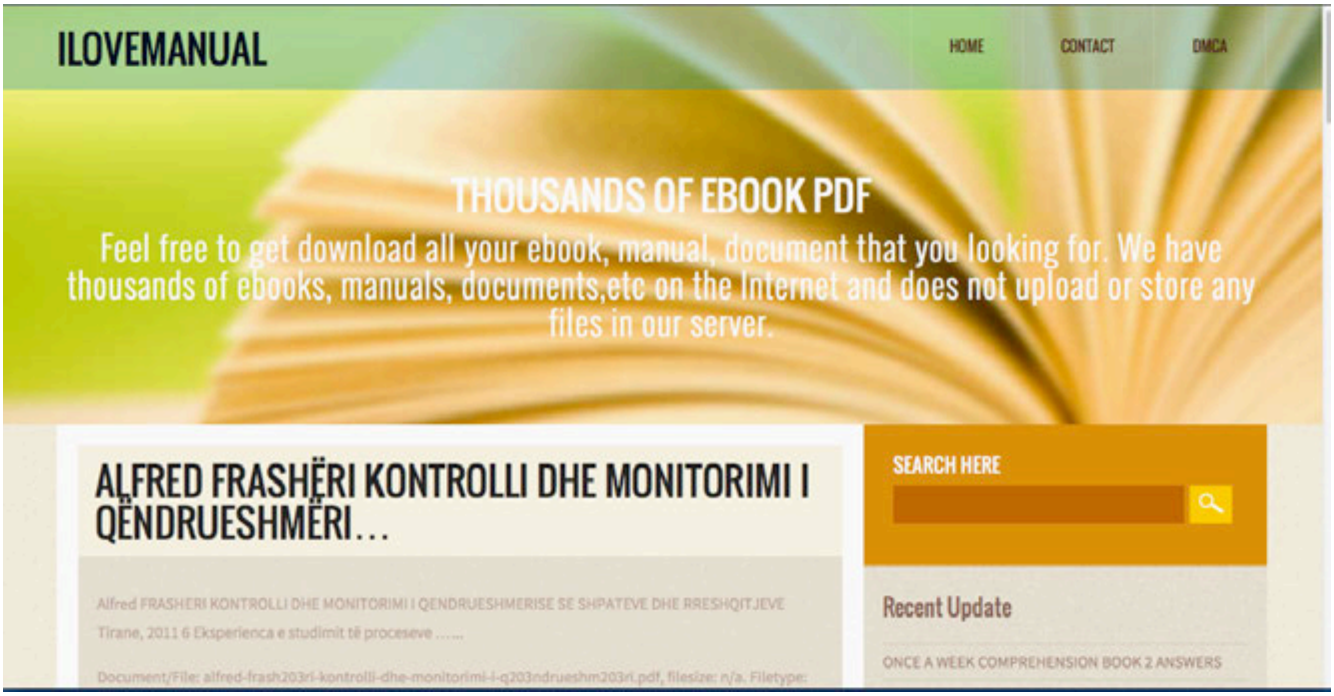
1509

Anekse

LIBRAT QE JANE VENDOSUR NE INTERNET DHE LINKET E TYRE

Alfred FRASHERI



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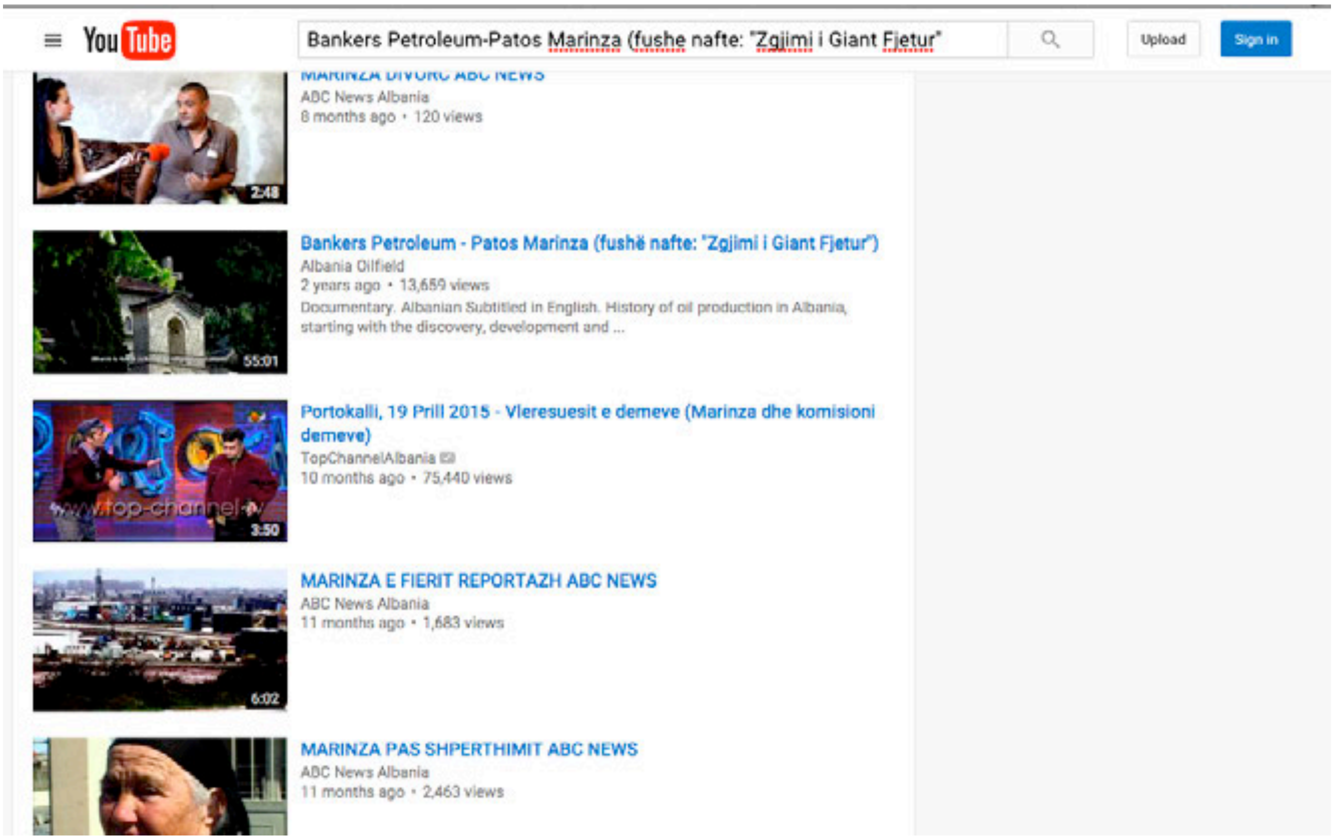

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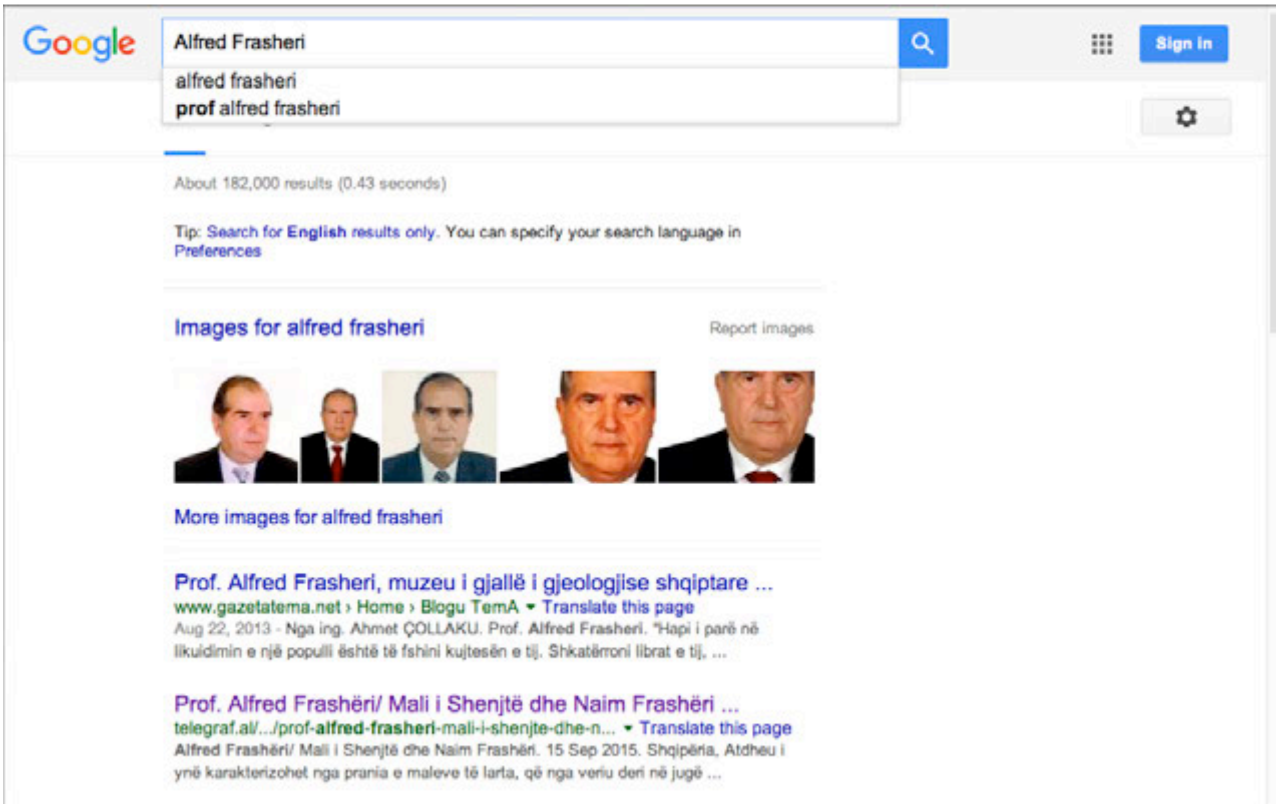

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Alfred Frashëri (lindur më 20 prill 1935, Korçë) është Inxhinier gjeolog i specializuar në gjeofizikë, doktor i shkencave, profesor.

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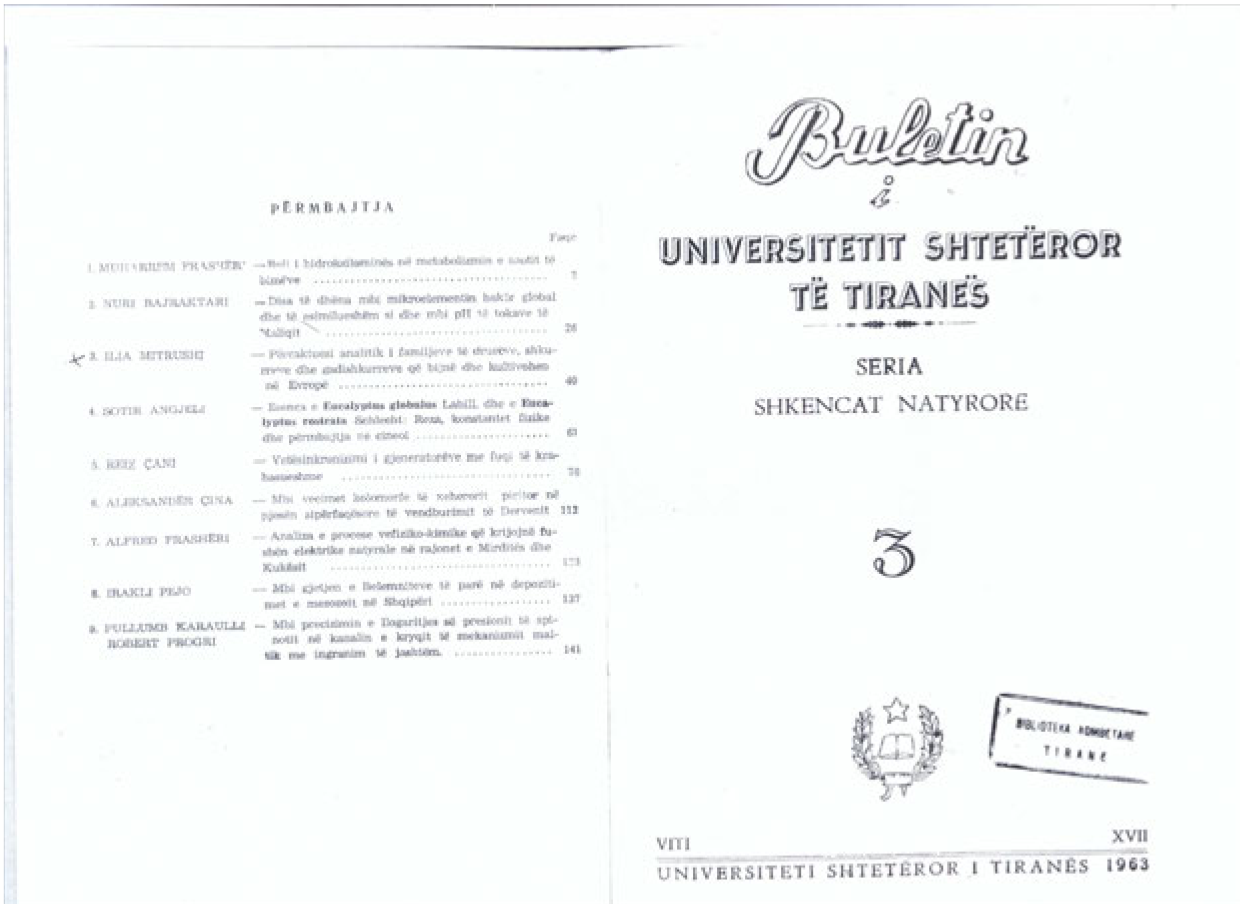

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ANALIZA E PROCESEVE FIZIKO-KIMIKE QË KRIJOJNË FUSHËN ELEKTRIKE NATYRALE NË RAJONET E MIRDITËS DHE KUKËSI

ALFRED FRASHERI
Katedra e Vend-burimeve dhe metodave të kërkimit.

Metoda e potencialit të fushës elektrike natyrale është një nga mc difikimet bazë, që përdoret në vendin tonë për kërkimin dhe kontur min e zonave dhe trupave xeherorë sulfide të bakërit të mbuluar ng deluvionet.

Në rajonet e Mirditës dhe Kukësit janë fiksuar një serë anomalis të potencialit negativ të fushës elektrike natyrale. Duke u bazuar n analizën e materialit gjeofizik dhe në rezultatin e punimeve mineral të hapura për verifikimin e tyre, këto anomali në bazë të natyrës s tyre i klasifikojmë si më poshtë:

1. Anomali të cilat lidhen me mineralizimin sulfid.
2. Anomali të cilat lidhen me proceset e difuzion-adsorbimit dh filtrimit:
   a.) Anomali që lidhen kryesisht me proceset e difuzion-adbimit n gëlqerorët.
   b.) Anomali që lidhen me proceset e filtrimit dhe difuzion-adsorbi mit në prishjet tektonike.
3. Anomali që kondicionohen nga relievi, anomali të fushës elektri ke natyrale, që ndryshojnë me kohën.

1. Anomali që lidhen me mineralizimin sulfid.

Anomali të tilla fiksohen mbi zonat e mineralizimit sulfid, që da lin në sipërfaqe ose janë të mbuluara nga deluvionet (fig. 1, 2, 3, 4, 5, 6 7) dhe kanë konfiguracion, potencial dhe gradient të potencialit të fushës elektrike natyrale të ndryshëm.

Duke analizuar të dhënat e zbulimit gjeollogjik, studimet mineragrafike dhe mineralogjike, vihet re se parametrat e më sipërm kondicionohen nga forma gjeometrike e zonës dhe trupave xeherore,, pozicioni, përbërja mineralogjike dhe struktura e trupit xeheror, gradient i vetive oksido-reduktuese së ambjentit jonik, që rrethon trupin xeheror në kufijt e tij, nga çarshmëria e shkëmbijve anësorë dhe formës së relievit.

Megjithë ndryshimet e mëdha të faktorëve që përmendëm më sipër, anomalitë e potencialit të fushës elektrike natyrale mbi këto zona lindin si rezultat i disa proceseve, të cilat në përgjithsi janë të ngjajshme për të gjitha zonat:

a. Proceset oksido-reduktuese.
b. Procesi i adsorbimit
c. Procesi i filtracionit.

Vlen të theksohet që në fillim, se këto procese zhvillohen në shkallë të ndryshme në objekte të ndryshme:

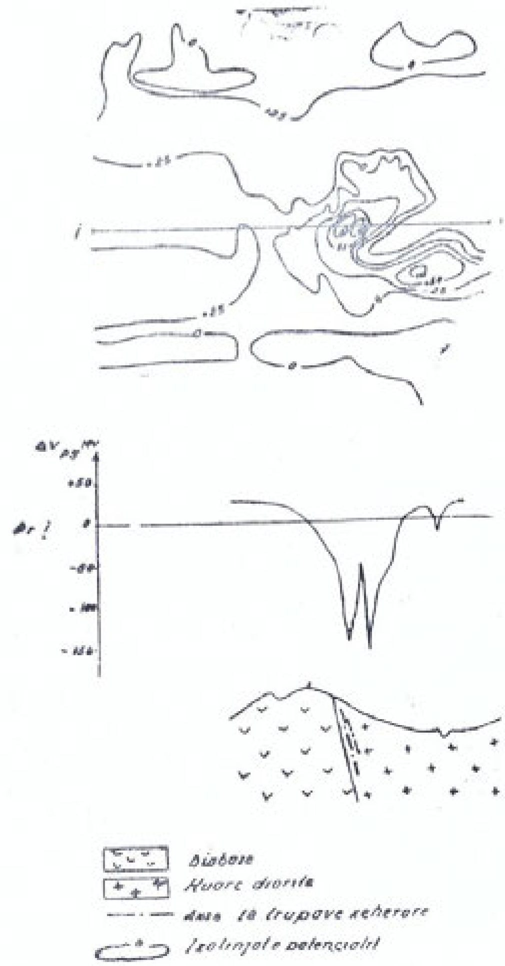

Fig. 1

Në fig. 1 jepet anomalia e potencialit të fushës elektrike natyrale mbi një zonë me mineralizim sulfid. Mineralizimi në këtë zonë përfaqësohet nga damarë kuarci dhe kloritesh me përmbajtje të konsiderueshme të sulfideve në formën e damarëve të piritit bakër mbajtës dhe kalkopiritit. Si shkëmbij anësorë janë kuarc dioritet. Në vend-burim takohen shumë ceolitet, të cilët kanë filluar të shndrohen në prenit dhe në shkallë shumë të vogël në kaolinë. Proceset fizike në sektorë të ndryshëm, janë zhvilluar me intensivitet të ndryshëm.

Në këtë zonë, në pjesën e sipërme takohen hidrokside të hekurit, kryesisht limonit (por theksojmë se nuk është zhvilluar në mënyrë të plotë kapella e hekurit) më poshtë takohet hematit. Në sasi shumë të vogël vihen re sulfide sekondare, kryesisht kalkozine.

Reaksionet e oksidimit në këtë zonë zhvillohen intensivisht, si rezultat i ekzistencës së sulfideve të hekurit dhe bakrit në kontakt e bashkërisht me njeri tjetrin. Por me qenë se piriti ka potencial (ndaj një teli bakri) + 0,18 volt dhe kalkopirti ka potencial + 0,18 — 0,30 volt, sipas shkallës së Gottshllak dhe Bjuçler f.m. e zhvilluar kur dy sulfidet ndodhen në solucion, tenton të shpejtojë oksidimin dhe tretjen e sulfidit me potencial më të vogël d.m.th. të piritit dhe vonojnë oksidimin e kalkopiritit. Në këtë mënyrë, në rastin tonë, oksidohet më shpejt piriti. Këtë fenomen e ndihmon edhe sasia më e madhe e piritit, në trupin xeheror. Reaksionet dhe rruga e oksidimit janë të njëllojta si edhe për të gjitha vend-burimet sulfide (1, 2, 4, 5, 11, 12), por për objektin e dhënë rolin kryesor e luajnë kationet e hekurit. Kationet e bakrit luajnë një rol të dorës së dytë. Këtë gjë e vërteton edhe fakti, që sulfidet sekondare të bakrit takohen shumë pak, d.m.th. sulfati i bakrit ka vepruar në shkallë më të vogël mbi kalkopiritin, sesa sulfati i hekurit mbi piritin.

Për objektin e fig. 1 rëndësi të madhe, në krijimin e fushës trike natyrale, luan edhe procesi i adsorbimit.

Rolin kryesor në këtë proces e luajnë ceolitet, karakteristikë çantë e të cilave është lehtësia me të cilën ndodh shkëmbimi r kationeve, që ekuilibrojnë ngarkesën negative të karkasës së kristalin dhe kationeve në solucionin ujor, që ndodhet për rret rrugë tjetër e fiksimit të bakërit në pjesën e sipërme të zonës sidimit është edhe adsorbimi i tij nga lëndët e shumta me dispen lartë si limotitet, kaolini etj. të cilët gjithashtu tentojnë të largoj tionin e Cu nga solucioni.

Në këtë mënyrë kationi i bakrit duke u adsorbuar nga këta ralë, formon rreth tyre një cipë të dyfishtë elektrike, pjesa e s e së cilës është ngarkuar negativisht.

Në këto objekte është vënë re gjithashtu edhe ekzistenca e të holla të sulfideve sekondare rreth kristaleve të kalkopiritit. F tregon mbi adsorbimin në mënyrë zgjedhëse të kationeve të bakë kalkopiriti dhe krijimin e cipave të dyfishta elektrike. Në zonën sidimit krijohet gjithashtu cipë e dyfishtë elektrike edhe si re adsorbimit në mënyrë zgjedhëse të kationeve të hekurit nga pir

Të gjitha këto cipa të dyfishta elektrike intensifikojnë an e potencialit të fushës elektrike.

Proceset e filtrimit lozin gjithashtu një rol të madh në obj fig. 1. Ekzistenca e ceoliteve në objekt ndron deri diku ligjësh e përgjithëshme, që rryma elektrike lëviz në drejtim të kundërt s sin e lëvizjes së ujit që filtron. Duke qenë se ceolitet adsorbojnë k ujrat do të transportojnë më tepër anionet, pra pjesët e sipërme kenë potencial më të lartë se pjesët e poshtëme, kështu rryma e do të lëvizë në të njëjtin drejtim me rrjedhjen e ujit. Kjo gjë ka tuar zvogëlimin e amplitudës së anomalisë së potencialit të fush trike natyrale.

Bashkësia e të gjithë këtyre proceseve ka shkaktuar, që mb minerale në objektin e fig. 1 të lindë fushë elektrike natyrale e me. Potenciali i saj në epiqendrën e anomalisë arrin në 160 m se gradienti varion nga 0,5 $\div$ 25 mv/m. Për të krijuar një anom që intensive ka influencuar edhe fakti që xeherori paraqitet m zime të dendura deri në masiv, pra ka përcjellshmëri elektrike të. Rezistenca elektrike specifike e trupit xeheror është rreth 0, ndërsa raporti në mes rezistencës elektrike specifike të xeher ambjentit rrethues (kuarc diorite) është rreth 1.1 x 10^{-3} om

Anomali intensive e fushës elektrike natyrale është fiksuar objektin e treguar në *fig.* 2. Ky objekt ndryshon rrënjësisht nga i më sipërmë. Zona minerale e objektit lidhet me shkëmbijtë që rrethohen nga shiste argjilore-silicore. Xeherori përbëhet k nga piriti dhe kalkopiriti dhe është i tipit me pikëzime të dend në masiv. Takohen edhe pikëzime mesatare.

Shkëmbijtë efuzive janë kryesisht të kuarcizuar, kloritizu citizuar dhe hematitizuar. Zona minerale afër sipërfaqes është o por oksidimi në pjesë të ndryshme është në faza të ndryshme. sën e sipërme zona është në fazën përfundimtare, në shumë sel thellë vihet re faza mesatare dhe fillestare. Në pjesën e sipërm hen sulfide sekondare të përfaqësuara nga kovelina dhe kalko: përqindje të konsiderueshme.

Pra proceset e oksidimit janë zhvilluar me intensivitet

Në përgjithësi ruhet skema e përgjithshme me ndryshim, që solucionet janë me acide dhe se sulfati i bakrit vepron mbi kalkopiritin dhe formohet edhe kovelinë:

$$CuFeS_2 + CuSO_4 = 2Cu_2S.\ CuS + FeSO_4$$

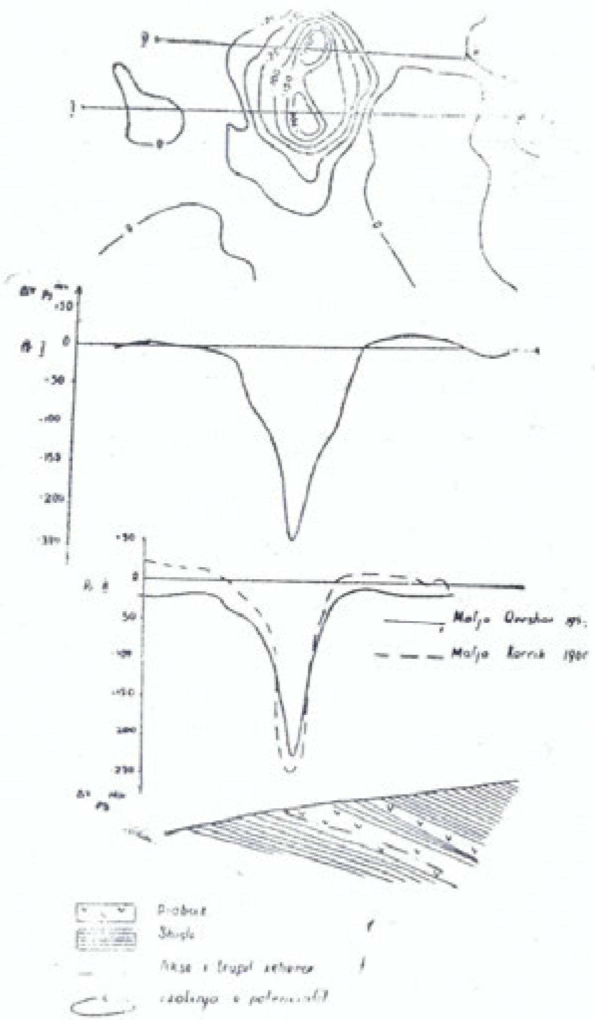

Fig. 2

pra bakri reduktohet. (12) Kështu përveç kationeve të hekurit, në krijimin e fushës elektrike natyrale në këtë objekt, luajnë një rol me rëndësi edhe kationet e bakërit.

Cipat e dyfishta elektrike në këtë rast kondicionohen kryesisht nga absordimi i kationeve të bakërit nga limoniti dhe kaolini.

Në këtë objekt, procesi i filtrimit influencon për zmadhimin e potencialit të fushës elektrike natyrale. Anomalia mbi këtë zonë minerale ka potencial deri — 280 mv. dhe gradient potenciali 0,5 ÷ 44 mv/m. Edhe në këtë rast trupi xeheror ka përcjellshmëri elektrike të lartë. Rezistenca elektrike specifike është 0,3 om.m.

Në objektet e treguara në fig. 3,4 potenciali i fushës elektrike natyrale është gjithashtu i madh. Në objektin e fig. 3 trupat xeherore lidhen me shkëmbijtë efuzivë (Porfirite, keratofire dhe porfire kuarcore) të ndryshuar në rrugën hidrotermale. Xeherorimi sulfid përfaqsohet nga pikëzime, fole, damare piriti dhe kalkopiriti. Në shkëmbijtë, krahas xeherorit, përmbahet edhe helmatit e manjetit. Në zonën e oksidimit takohen sulfide sekondare të përfaqsuara nga kalkozina, kovelina, takohet gjithashtu bakër nativ, kuprit, mallahit, azurit dhe hidrokside hekuri. Zona e oksidimit është zhvilluar shumë dhe hyn disa dhjetra metro në thellësi. Siç duket në fig. 3 potenciali në këtë anomali arrin në-205 mv.

Në objektet e treguara në fig. 2 dhe fig. 3, në rritjen e potencialit negativ ka influencuar shumë edhe prezenca e manjetit.

Deri në -225 mv. arrin potenciali objektin e fig. 4, në të cilin trupi xeheror përfaqësohet nga brekçe xeherorë-diabazikë që përbëhet

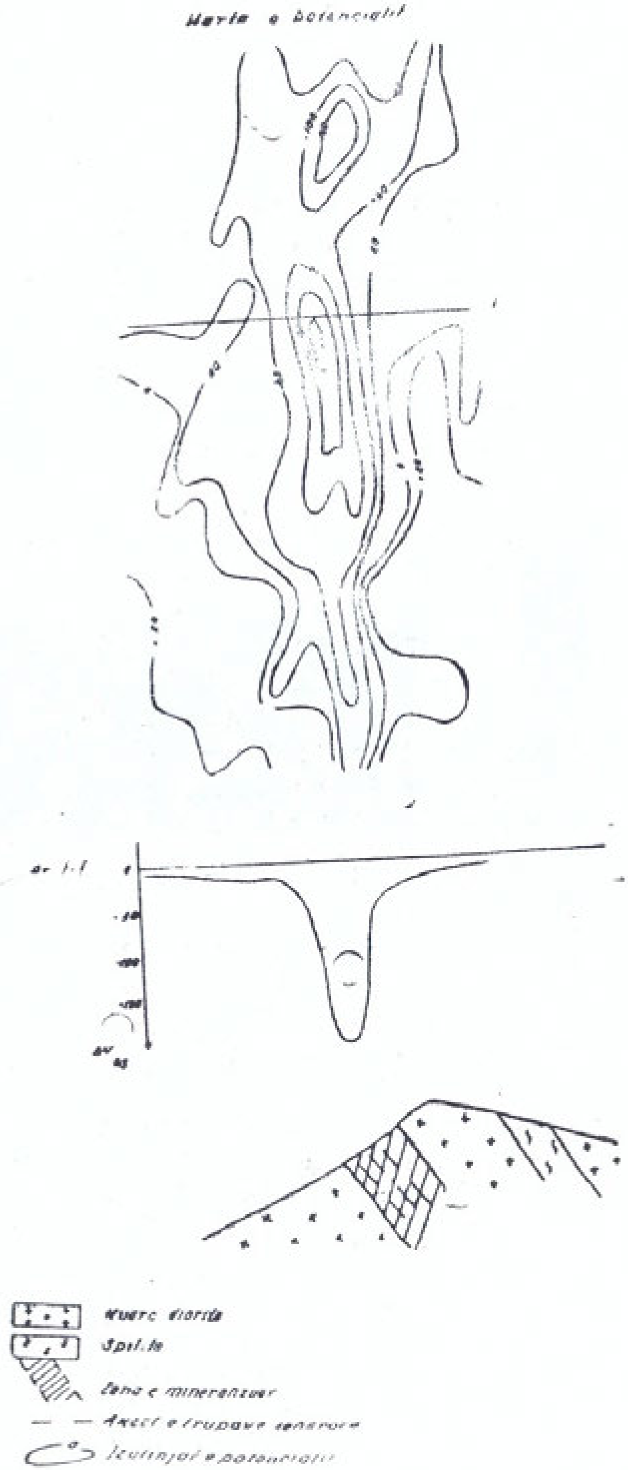

Fig. 3

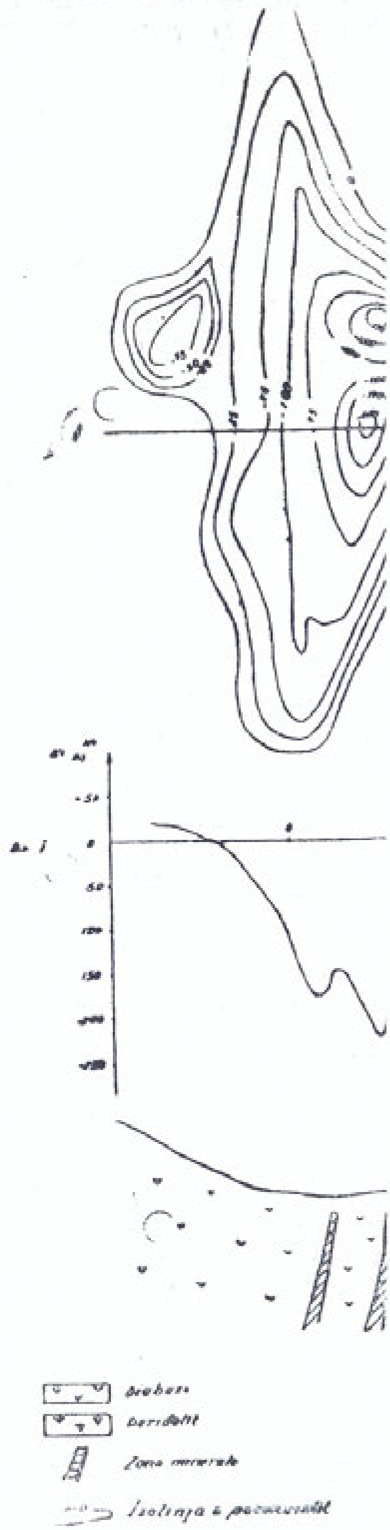

Fig. 4

nga copa me madhësi të ndryshme të xeherorit masiv pirit me mineralizimin sulfid dhe pikëzime piriti dhe diabaz. Zona e oksidimit është zhvilluar intensivisht dhe arrin në thellësi rreth 60-70 m. Mineralet sekondare takohen shumë pak dhe përfaqsohen kryesisht nga kovelina.

Është karakteristik fakti, që megjithëse në të katër objektet e mësipërme anomalia e potencialit të fushës elektrike natyrale është intensive, jo të gjithë kanë rëndësi industriale. *Kështu nuk mund të bëhet vlerësimi industrial kuantitativ i vendburimeve, duke u bazuar në të dhënat e fushës elektrike natyrale.*

Intensiviteti i anomalive të potencialit të fushës elektrike natyrale ulet në mënyrë të theksuar në rastet kur trupi xeheror përfaqsohet nga pikëzime mesatare dhe të ralla (fig. 5, 6). Kjo gjë shkaktohet për këto arsye:

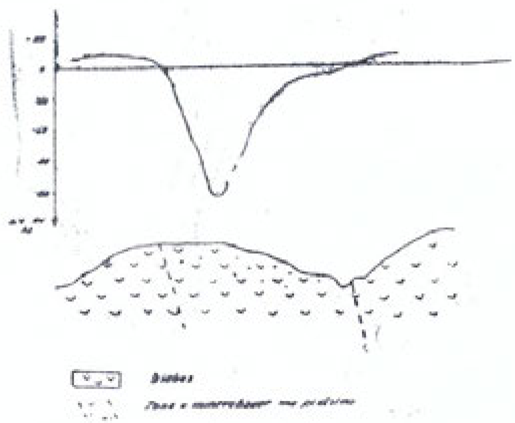

Fig. 5

1. Në këto zona minerale, proceset e oksidimit zhvillohen me intensivitet të vogël, mbasi pikëzimet e sulfideve nuk takojnë njera tjetrën.

2. Në intensivitetin e oksidimit influencojnë edhe faktorë të tjerë fizikë dhe kimikë, të cilët influencojnë në oksidimin, vetëm për vendburimin e dhënë ose një pjesë të tij. Në këta faktorë do patur parasysh: karakteri i trupit xeheror (përbërja minerale, veçoritë strukturale dhe teksturale), kondităt e shtrirjes dhe karakteri i shkëmbejve anësorë, relievi (forma e tij dhe në cilën anë është drejtuar relievi) klima lokale, tektonike etj.

3. Trupi ka rezistencë elektrike specifike të lartë 13-40 om. m.

Konfiguracioni i anomalive mbi zonat me pikëzime shpesh herë është izometrike (fig. 5). Ky fakt e shpije zgjidhjen e problemit para alternatives: anomalia lidhet me pikëzimet e sulfideve, që dalin në sipërfaqe, apo me trupa xeherorë masivë po që ndodhen në thellësi disa dhjetra metro?

Zgjidhja e kësaj alternative lidhet me një faktor tjetër. Është karakteristike, që në qoftë se zona e oksidimit ka potencë të madhe dhe pjesa e sipërme e saj është në fazën përfundimtare, potenciali në sipërfaqen e tokës zvoglohet, mbasi trupi xeheror i sulfideve primare (që kanë përcjellshmëri elektronike të madhe) është në thellësi të konsiderueshme. Po kështu në përgjithësi,kur zona e oksidimit është e zhvilluar dobët, fusha elektrike natyrale do të jetë jo intensive. Por vlen të theksohet se jo gjithnjë është kështu. Nëqoftëse në zonat e mineralizimit sulfit ekziston gradienti i vetive oksiduese-reduktuese në kufirin e trupit xeheror, atëhere mungesa ose potenca e vogël e zonës së oksidimit ndihmon në krijimin e fushave elektrike natyrale në sipërfaqen e tokës (4) (fig. 10).

Pra për zgjidhjen e alternativës së më sipërme duhet të kryhen punime plotësuese me metodën e profilimeve elektrike të kombinuara

dentuar lejon kryer'en e tyre) (që jo gjithënjë relievi i aksi studiohet hopi i potencialit në kufirin e trupit xeheror dhe oksido-reduktues i ujrave nën• tokësore.

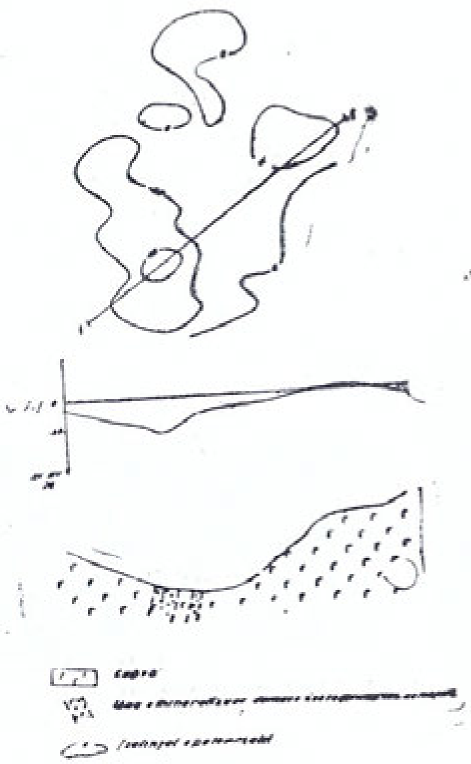

Fig. 6.

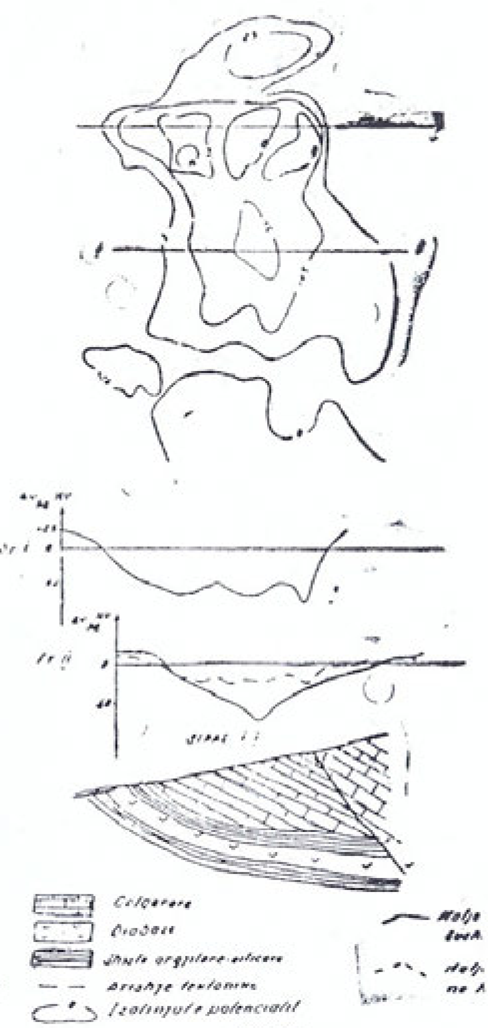

Fig. 7

Në lidhje me këtë është shumë e nevojshme dhe e domosdos që edhe në vendin tonë, krahas punimeve fushore të fillojnë, në f në baza eksperimentale, të caktohen këta parametra në kondita lal torike dhe fushore. Këto studime kanë rëndësi jo vetëm për kupt e proceseve, për të cilat u bë fjalë më lart, por por edhe për bazimin terpretimit të punimeve fushore.

2. Anomali që lidhen me proceset e difuzion-adsorbimit dhe filtrimit.

Në rajonin e Mirditës dhe të Kukësit janë fiksuar edhe një anomalish jo xeherore, që lidhen me ekzistencën e gëlqerorëve, pri tektonike dhe që kondicionohen nga relievi.

A. Anomali që lidhen kryesisht me proceset e difuzion-adsorb

Në *fig.* 7 jepet anomalia e fiksuar mbi gëlqerorët e Triasit t përmë. Ne mendojmë se anomalia mund të lidhet me procesin e

zion-adsorbimit. Duke qenë se gëlqerorët e Triasit të sipërmë janë të pastër (pa material argjilor), në të zhvillohet intensivisht fusha elektrike natyrale, si rezultat i krijimit të cipave të dyfishta elektrike, të ngarkuara nga ana e jashtëme negativisht. Këto cipa krijohen mbasi gëlqerorët adsorbojnë kationet e kalciumit dhe në solucion mbeten anionet e CO_3. Në rastin e objektit të fig. 7 influencojnë edhe potencialet e filtrimit, të ujrave nëpër gëlqerorët e Tr3, që janë shumë të çarë dhe kavernozë. Kjo gjë dokumentohet me matjet e kryera në të njejtin objekt. në vitin 1960 dhe 1961. Në fig. 7 tregohet se në profilin 11, potenciali i fushës elektrike natyrale është zvogluar gati dy herë, në vitin 1961, në krahasim me vitin 1960.

Ky zvoglim intensiv i potencialit tregon se niveli i ujit nëntokësor ka qenë i ndryshëm gjatë viteve 1960-dhe 1961, po kështu ka ndryshuar edhe intensiviteti i filtrimit të ujrave. Zvogëlimi i potencialit tregon se niveli i ujrave në vitin 1961 ka qenë më lart se në vitin 1960. Këtë konkluzion e vërteton edhe fakti që ndërsa në vitin 1960 matjet janë kryer në muajin Gusht, në vitin 1961 u kryen në Maj.

Komplikohet shumë problemi për zgjidhjen e një anëshme e detyrës, kur përveç natyrës së më sipërme të fushës elektrike natyrale mbi gëlqerorët, ka të dhëna favorizonjëse të mendohet se në diabazat, që shtrihen nën gëlqerorët, mund të takohet trup xeheror. Për të zgjidhur këtë problem duhen çpuar pa tjetër puse.

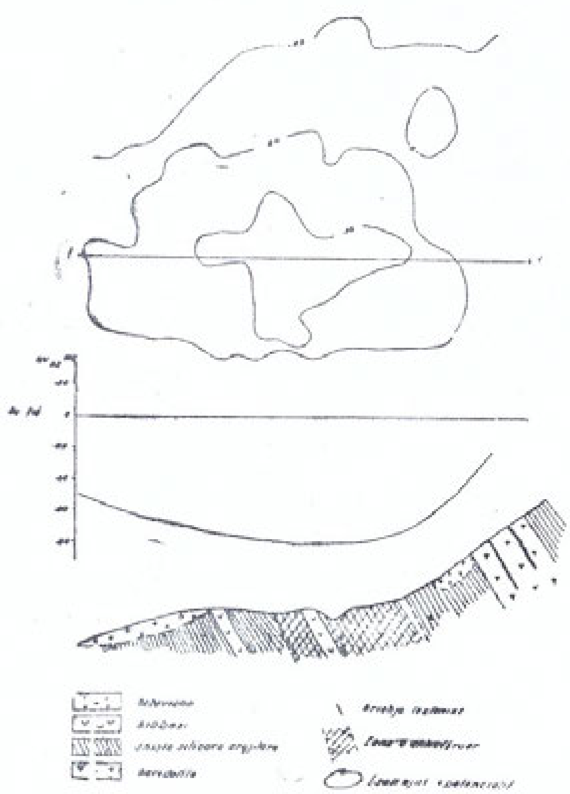

Fig. 8

Po vlen të theksohet se potenciali negativ intensiv i fiksuar mbi gëlqerorët nuk tregon gjithnjë se ata janë të çarë dhe kavernozë. Prezenca e potencialit negativ tregon në radhë të parë ekzistencën e gëlqerorëve të pastër (pa material argjilor) sesa gëlqerorëve të shkatrruar. Për të vërtetuar çarshmërinë e gëlqerorëve duhen kryer matje në kohë të ndryshme, kur niveli i ujrave nëntoksore ndron, pra mund të fiksohet potencial i krijuar për efekt të filtrimit.

b) *Anomali që lidhen me proceset e filtrimit dhe difuzion-adsorbimit*. Të tilla anomali vërehen gjithëmonë mbi zonat tektonikisht të shkatërruara (fig. 8). Në radhë të parë këto anomali lidhen me potencialet, që lindin në proceset e filtrimit të ujrave nëpër zonën e shkatrruar.

Është karakteristike fiksimi i anomalive intensive edhe mbi shl mbijtë ultrabazikë. Në zonën e shkatrruar të fig. 8 takohen breza serp tinitesh.

Mendojmë që përveç proceseve të filtrimit dhe difuzion-absorbin në këto raste luan një rol me rëndësi edhe prezenca e manjetitit sek dar. i formuar gjatë procesit të serpentinizimit e intersktcn masën shkëmbit me një seri damaresh të hollë. Në këtë mënyrë shkëmbi m përcjellshmëri elektrike të lartë, edhe kur përmbajtja e manjetitit ësl relativisht e vogël (4).

Në këto raste fusha elektrike natyrale do të lindë si rezultat i l pit të potencialit në kufirin e përcjellsit elektronik me ambjentin, i ka përcjellshmëri jonike. Është karakteristike, që këto anomali shoqë hen edhe me fushë manjetike intensive. Kështu në projektin e fig. fiksohet anomali e komponentit vertikal të fushës manjetike me amp tudë rreth 800 gama. Të tilla anomali janë fiksuar edhe në rajonet Rubikut dhe të Ulzës.

C — Anomali që kondicionohen nga relievi. = (fig. 9). Nga punimet e viteve të ndryshëm është vënë re se në pjesët e ngritura të relievit fiksohen anomali negative të potencialit në fushën elektrike natyrale, amplituda e të cilave arrin deri në-250 mv. ose për një disnivel 450-500 m. fiksohet një gradient potenciali 250 mv/km. Këto anomali lidher me fushën e filtracionit që vërehet gjithnjë në rajonet malore dhe në luginat e lumejve e prenjëve. Këto fusha janë intensive në vendet ku takohen deluvione dhe aluvione.

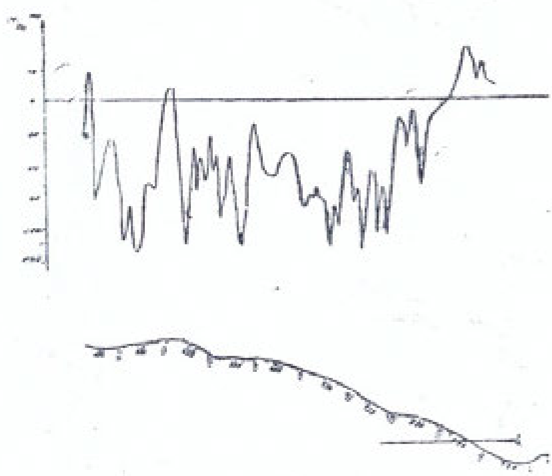

Fig. 9

3. Anomali të fushës elektrike natyrale që ndryshojnë me kohën

Gjatë punimeve fushore, shpesh herë vemë re se fusha elektril natyrale ndryshon me kohën. Në rajonet ku deluvionet nuk i kaloji 0,5 m. në shpatet e maleve të çveshur, në ditët e nxehta, kur temper tura nga mëngjezi në drekë ndryshon shumë, është vënë re mospë puthja e matjeve kryesore të kryera në mëngjez dhe matjeve të ko trollit në mes dite, ose vrojtimeve të kryera për lidhjen ditore të prof leve.

Ky ndryshim i fushës elektrike natyrale zakonisht, shkon në n drejtim, por në pika të ndryshme ka intensivitet të ndryshëm, i ci varion nga 5-20 mv. Është vënë re se sfondi i potencialit negativ vrojtur në mëngjez-bëhet pozitiv në kohën e mesditës. Ky ndryshim l dhet me oshilimet e temperaturës dhe si rezultat i kësaj me ndrysh min e lëvizjes së ujit në kapilaret e shkëmbejve në sipërfaqen e tok

(1-2 m. e sipërme). Vlen të theksohet se ky ndryshim nuk duhet të lidhet në asnjë mënyrë me mospërputhjen e matjeve të kontrollit, të mara si rezultat i punës pa kujdes së operatorit.

Në mënyrë që ky ndryshim i potencialit të mos influencojë në lidhjen e përditshme, duhet, që lidhja në profilin e mëparshëm të kryhet afërsisht në po atë orë, kur është vrojtur profili një ditë më parë.

Siç u tregua në fig. 7, fusha natyrale, që ndryshon në kohën, është fiksuar edhe mbi gëlqerorët e Tr3, si rezultat i ndryshimit të nivelit të ujit të nëntokës, pra i ndryshimit të potencialit të filtrimit.

Është shumë karakteristik rasti i ndryshimit të potencialit të fushës elektrike natyrale, mbi një pikë me mineralizim sulfid polimetalik (fig. 10).

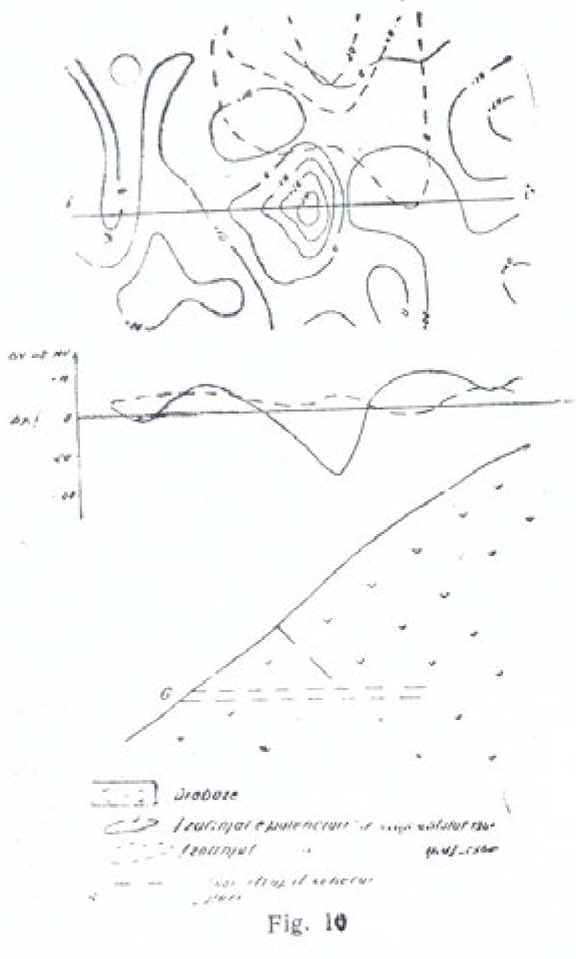

Fig. 10

Në këtë pikë mineralizimi përfaqsohet nga xeherorë masivë piriti, kalkopiriti, sfaleriti, galeniti dhe lidhet me diabazët. Në objekt nuk takohen sulfide sekondare dhe hidrokside hekuri. Për më tepër, në sipërfaqe takohet sfalerit i pandryshuar. Kjo tregon se zona e oksidimit nuk është zhvilluar fare. Mendojmë se kjo lidhet me faktin që shpejtësia e oksidimit është më e vogël se shpejtësia e erodimit, i cili ndihmohet nga relievi i pjerët dhe qarkullimi i shpejtë i ujrave.

Megjithëse zona e oksidimit mungon, në vitin 1961 u fiksua anomali negative e potencialit të fushës elektrike natyrale me amplitudë — 36 mv.

Anomalia ekziston si rezultat i gradientit oksidoreduktues në kufirin e trupit xeherор, i proceseve të difuzion-absordimit dhe filtrimit.

Megjithëse trupi xeheror është masiv, intensiviteti i anomalisë është i vogël. Ky fakt mund të shpjegohet nga dy arësye:

a) Dimensionet e trupit mund të jenë të vogla:

b) Duke qenë se sfaleriti ka potencial (ndaj një teli bakri) — 0,2-0,4 volt dhe galeniti + 0,15 volt. (5, 7, 11) rradha e oksidimit do të jetë:

$$ZnS > PbS > FeS_2CuFeS_2$$

Kationet e Zn^{++} luajnë rol me rëndësi në krijimin e fushës elektrike natyrale për efekt të difuzion-adsorbimit.

Galeniti duke u oksiduar jep sulfate të tretshëm me shumë vështi-

rësi në solucione p.sh. anglezitin, i cili është produkt i parë i oksic
mit të galenitit, që në prezencë të $Ca(HCO_3)_2$ ose CO_2, të cilët ndodh
në solucion mbasi një pjesë e ujrave nëntoksore, në objekt, kalojnë n
për gëlqerorët e Kredës, gradualisht zevendësohet nga cerusiti, që g
thashtu është i patretëshëm në solucion. Këto sulfate dhe karbonate
veshin kristalin e galenitit me një cipë të patretëshme dhe me përcje

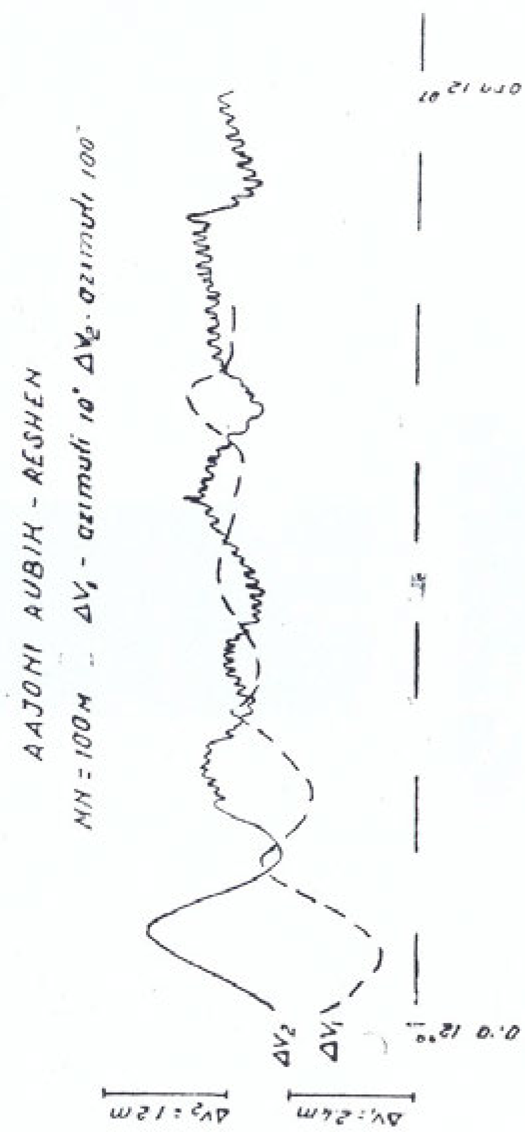

Fig. 11

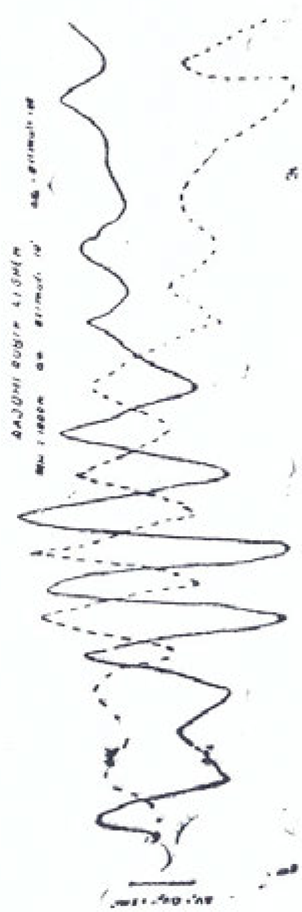

Fig. 12

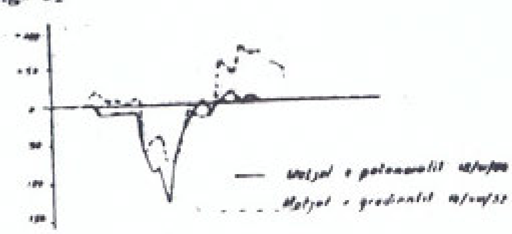

Fig 13

shmëri elektrike të keqe (4). Në këtë mënyrë vështirsohet procesi i oksidimit të mëtejshëm dhe takimi i solucioneve oksidues në kufirin e përcjellësit, dhe kështu i jepet në përgjithësi trupit xeheror përcjellshmëri e keqe elektrike. Kjo gjë shkakton zvoglimin e potencialit, në pjesët e trupit të pasura me galenit.

Por vlen të theksohet se objekti ndodhet në fillimin e studimit të tij, pra këto konkluzione paraprake mbështeten në ato pak të dhëna jo të plota, që kemi deri tani. Në të ardhmen kur të merren të dhëna më të plota, këto konkluzione do të preçizohen.

Po kështu sfaleriti, si mineral me përcjellshmëri të keqe elektrike, influencon në uljen e intensitetit të anomalisë (4).

Mbasi u kryen punimet gjeofizike në vitin 1961, në objekt u hap një galeri. Mbas hapjes së galerisë, në vitin 1962 (shih fig. 10) u kryen përsëri punime elektrometrike. Mbi Pr. 1 i cili kalon përmbi trupin xeheror u fiksua një anomali e vogël pozitive (potenciali +4 mv.). Ky ndryshim i fushës elektrike natyrale me kohën, mendojmë se lidhet me dy fakte:

1) Si rezultat i hapjes së galerisë u formua hinka e depresionit, kështu që tashmë oksidohet më intensivisht pjesa më e thellë e trupit xeheror, ndërsa në pjesën e sipërme trupi xeheror oksidohet shumë ngadalë. Kjo gjë shkakton zvogëlimin e anomalisë.

2) Ulja e nivelit të ujrave nëntoksore sjell rritjen e koncentrimit të joneve në pjesën e sipërme dhe zvoglimin e koncentrimit në pjesët e poshtëme. Potenciali i difuzionit, i krijuar në këtë rast, do të shkaktojë që anomalia e dobësuar të marrë shenjë negative.

Vlen të theksohet se raste të tilla vihen re jo vetëm afër minierave dhe galerive, por edhe në sektorët ku ndrron baza e errozionit. Prandaj, në punimet fushore duhen analizuar me kujdes të gjitha anomalitë, si negative ashtu edhe pozitive.

Në rajonet e Mirditës dhe të Kukësit është vënë re gjithashtu ekzistenca e rrymave telurike. Këto rryma vërehen zakonisht kur distanca midis elektrodave M N është më e madhe se 500m. Në kohët kur këto rryma janë të pa rëndësishme, kanë potencial rreth 0,6 mv. *(Fig. 11)* por në orë të caktuara ato bëhen shumë intensive. Potenciali i tyre arrin deri në 5 mv. *(fig. 12)* me frekuencë rreth 5 periudha në minutë. Kur ato janë shumë intensive, potenciali i tyre i kalon të 10 mv. Siç shikohet, në këto raste, potenciali i fushave telurike e kalon preçizionin e matjeve fushore, pra ul saktësinë e punimeve dhe vështirëson vrojtimet fushore.

Në këto raste nuk mund të punohet me linja MN me të mëdha se 500 m. Por duke punuar me linja të vogla, ulet rendimenti dhe shtohen vrojtimet për lidhjen e planshetave.

Është vënë re që rrymat telurike nuk intensifikohen vetëm ditën por edhe natën. Kështu në rajonin e Lisit, Kolonjës etj. janë vrejtur fusha telurike me potencial deri 5-6 mv. edhe natën, në orët 2-3. Ne mendojmë se intensifikime të tilla lidhen me furtunat manjetike.

Prandaj, në objektet me sipërfaqe të mëdha, kur kryhet rilevimi në shkallën 1 : 10.000 të filohet eksperimentimi dhe pastaj të kalohet në punime prodhimtare me modifikimin e gradientit të potencialit të fushës elektrike natyrale. Rezultatet e marra gjatë vrojtimeve me potencialin dhe gradientin e potencialit të fushës elektrike në vitin 1962, (fig. 13), siç pritej ishin të mira dhe saktësia e këtij modifikimi do të rritë preçizionin e matjes, do të ulë koston e punimeve në mënyrë të ndjeshme dhe, (si rezultat i shkurtimit të brigadës së punës, mos

përdorimit të telave me gjatësi të madhe), do të rritë rendimentin në

Në këtë artikull 1) është përdorur plotësisht materiali i pun gjeofizike me metodën e fushës elektrike natyrale (3.9,10), në kr e të cilave autori ka marrë pjesë direkte.

(Paraqitur në Redaksi më 21-V-196

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1) Grumbulimi dhe përpunimi i materialit faktik është bërë nga ing. fizik Esat Daja, të cilit autori i shpreh falenderimet. Po kështu autori fal ign. Aleksandër Çina, gjeoll. Petro Kati, Kand shkenc. mineralogjike-gje Skënder Dede për ndihmën e madhe, në drejtimin e dhënies së materialeve dimeve mineralografike-mineralogjike, ingjinierëve gjeofizikë Ligor Lubonj Biçoku dhe gjeol. Zihni Sinoimeri, autori u shpreh mirënjohjen e thellë për shumë të vlefshme.

Résumé

ANALYSE DES PROCES PHYSICO-CHIMIQUES CREANT LE CHAMP ELECTRIQUE NATUREL DANS LA MIRDITA ET KUKES

La méthode du champ électrique naturel est, à tout ce jour, une des modifications qui a trouvé un large usage en Albanie dans les recherches et le tracé des conteurs des zones et des corps minéraires du sulfite de cuivre recouvert pas les déluvions.

Dans certains arrondissements on a fixé une série d'anomalies du chàmp électrique naturel. Ces anomalies, l'auteur les classifie, sur la base de leur nature, comme suit:

1) Anomalies dues à la minéralisation des sulfites;

2) Anomalies dues notamment aux procès de la diffusion-adsorbtion et de filtrage;

a) anomalies dues notamment aux procès de diffusion-adsorption chez les calcaires.

b) Anomalies dues aux procès de filtrage et de la diffusion-adsorption dans les cassures techtoniques.

3) Anomalies conditionnées du relief, anomalies du champ électrique naturel, variant avec le temps.

Dans les cas où l'anomalie du champ électrique naturel, dans la quasi-totalité des objets de travail, outre les réactions d'oxydo-réduotion, influe à divers échelons les pocés de diffusion-adsorption et de filtrage.

Dans les objets, où les roches latérales renferment des minéraux de zéolite, on remarque leur influence sur l'intensité des anomalies. Ces minéraux, agissant en filtres atomiques, influent sensiblement sur les procès de diffusion-adsorption et de filtrage.

Dans certains cas on a fixé des anomalies du champ électrique naturel sur les roches ultrabasiques, comme suite du magnétite centenu en elles.

Dans des objets particuliers on a fixé le champ électrique naturel variant avec le temps. Cette variation est due à celle du niveau des eaux souterraines, à l'influence des travaux minéraires (formation d'entonnoirs de dépression), à la concentration variée des solutions autour du corps minéraire.

L'auteur est de l'avis que sur les corps minéraires polymétalliques renfermant de la galénite et de la blende, n'ont pas lieu des réactions physico-chimiques qui créent des anomalies positives.

Nombre d'anomalies sont dues aux procès de diffusion-adsorbtion et de filtrage.

La méthode du champ éléctrique naturel n'a pas donné des solutions unilatérales du problème. Toutefois, cette méthode doit être employée, en concordance avec les autres méthodes d'électrométrie, aussi dans l'avenir, pour les recherches des zones minéraires recouvertes par les déluvions.

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APLIKIMI I METODAVE TË REJA GJEOFIZIKE PËR KËRKIMIN E KROMITEVE NË PJESËN VERIORE TË SHQIPËRISË

Ligor Lubonja – Alfred Frashëri
Katedra e vendburimeve

Për kërkimin e trupave qorre të kromiteve në vendin tonë, janë krye gjatë viteve 1957/59 punime magnetometrike dhe gravimetrike, rezultatet e të clave në përgjithsi kanë qenë negative. Këto punime u kryen nga ekspedita e Komitetit Shtetëror të Gjeologjisë.

Duke patur parasysh detyrat e ditës në kërkimin e kromiteve, në vitin 1962 u përdor përsëri metoda e magnetometrisë dhe u eksperimentua për herë të parë metoda e re e polarizimit të provokuar. Këto punime u kryen nga ekspedita gjeofizike e Ndërmarrjes Gjelogo-Topografike në bashkëp[unim me Laboratorin e Gjeofizikës në Universitetin Shtetëror të Tiranës.

Në këtë artikull jepet analiza e punimeve të viteve 1957/59 dhe rezulatet e punimeve të vitit 1962.

1. NDËRTIMI GJEOLOGO-PETROGRAFIK I TRUPAVE DHE ZONAVE MINERALE

Shkëmbinjtë që ndërtojnë vendburimet e kromiteve, përfaqësohen nga një kmpleks intruziv i shkëmbinjve ultrabazikë. Dunitet janë shkëmbinjtë kryesorë që përmbajnë kromitin dhe takohen në formë veçimesh në masën e përidotitëve.

Kontakti i duniteve me serpentinitet aperidotit në përgjithësi është gradual, megjithëse kemi raste kur kontaktet janë të qartë. Struturat primare të shkëmbinjve shumë herë janë prishur krejtësisht, si rezultat i zhvillimit intensiv dhe të plotë të proçesit të serpentinizimit, proçes i cili në disa rastë sjell formimin e makrostrukturave rrjetore. Në përgjithësi, përbërja mineralogjike është e thjeshtë dhe në të shumtën e rasteve është e qëndrueshme.

Duke studiuar përbërjen mineralogjike të duniteve vihet re zhvillimi i madh i serpentinës prej olivine, si përbërës kryesor i shkëmbit. Si minerale sekondare takohet brucit dhe minerale metalore (magnetit ne formë pluhuri). Përhapje shumë të madhe kanë peridotitët.

Grada e serpentinizimit të tyre është e ndryshme, shpesh herë takohen serpentinite apoperidotite. Në përbërjen mineralogjike të këtyre shkëmbinjve bën pjesë serpentine prej olivine, serpentine prej pirokseni, magnetite në sasi të vogël dhe kokrriza krom-shpineliti 2-3%. Në peridotitet, aty këtu, vërehen shlire dunitesh.

Në vendburimet takohen damarë piroksenitesh, në përbërjeb e të cilëve merr pjesë pirokseni rombik dhe monoklin, rrallë takohen edhe dajka gabbro-pegmatitesh.

Trupat xeheroë përfaqësohenga kromitet me pikëzime të rralla, mesatare dhe të dendura, me teksturë nodulare, brezore deri në kromit masiv. Xeherori përfaqësohet nga kromshpimeliti me sasi të ndryshme të olivinit, serpentinit, më rrallë talkut, kloritit, opalit. Nga një herë kokrrizat e kromitit rrethohen me cipë magnetite, që ka lndur si rezultat i veprimeve dinamike të fuqishme.

Mineraket xeheror formues, kromshpineliti, ka formë idiomorfe me kokrriza në formë kuadratesh në prerje dhe rrallë takohen kseno-kristale.

Trupat zeherorenë përgjithësi kanë formë damarrësh dhe lentesh me dimensone të ndryshme, që shpesh herë variojnë me kufinj të gjerë dhe brenda një trupi. Përshembul, takohen trupa që gjatë rënies zgjaten sa pesë gjashtë herë potenca e tyre dhe gjatë shtrirjes sa dhjetë pesëmbëdhjetë herë potenca. Trupat kanë shtrirje në përgjithësi V.VP-J.JL dhe bien me kënde nga 25° deri në 80°-85°. Gjatë shtrirjes ata lakohen me kënde që variojnë në kufi të gjerë.

Së bashku me trupat xeherorë me potencë të madhe takohen edhe apofiza xeherore të ndara nga duniti, që në të shumtën e rasteve janë paralele me trupin xeheror kryesor. Si rregull, në shumixën e rastëve janë paralele me trupin xeheror kryesor. Si rregull, me rritjen e potencës së trupave xeherorë, zvogëlohet potenca e brezave të dunitit që intersektojnë trupin.

2. VETITËZIIZIKE TË SHKËMBINJVE DHE XEHERORIT

Shkembinjtë që ndërtojnë vendburimet e kromiteve u janë nënshtruar veprimeve të ndryshme dinamikë, si rezulat i të cilave shkëmbinjtë kanë shkallë të ndryshme serpentinizimi dhe të përmbajtjes së magnetitit. Ky ndyshim ka shkaktuar që vetitë fizike të shkëmbinjve dhe xeherorëve të variojnë në kufinj të gjerë.

Dunitet e serpentinizuar dobët e deri të serpentinizuar shumë dhe harcburgitet kanë predspozitet magnetik χ=100 x 10^{-6} deri 1000 x 10^{-6} CGSM [7]. Me rritjen e serpentinizimit rritet edhe peredspoziteti magnetik. Kështu, dunitet e serpentinizuar kanë predspozitet χ=150 x 10^{-6} CGSM, kurse dunitet e serpentinizuar shumë kanë χ=500 x 10^{-6} CGSM (Shih fig. 1).

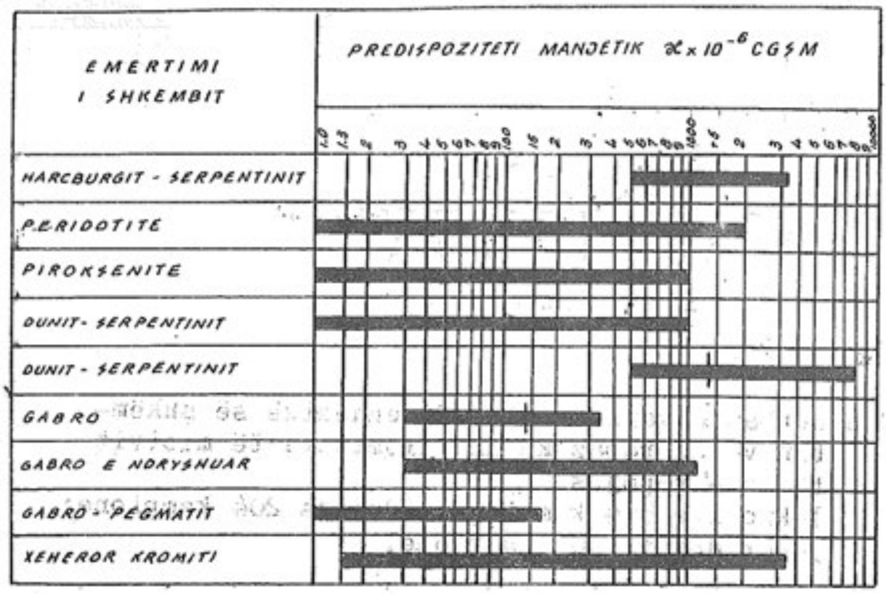

Fig. 1. Predspoziteti magnetik i shkëmbinjve ulrabazikë, bazikë dhe xeheror të kromit [7].

Një rol të rëndësishëm ka luajtur përmbajtja primare e magnetitit, mjafton të përmëndim vetëm se 0,1% magnetit, mund të kondicionojë një χ=200 x 10^{-6} – 300 x 10^{-6} CGSM [7].

Kufinjtë brenda të cilëve lëkundet madhësia e predspozitetet të serpentiniteve janë spostuar në anën e vlerave të mëdha, kështu predspoziteti për serpentinitet prej duniteve varion nga një χ=500 x 10^{-6} deri 7500 x 10^{-6} CGSM [7].

Dunitet e serpentinizuar që përmbajnë pikëzime kromiti kanë predspozitet χ= 0 - 350 x 10^{-6} CGSM. Kjo ulje e predspozitetit magnetik mund të lidhet me përmbajtje më të ulët të magnetitit në krahasim me dunitet pa pikëzime. Po kështu, densiteti i duniteve varet nga shkalla e serpentinizimit. Densitetin më të vogël e kanë dunitet e serpentinizuar, σ = 2,0 – 3,5 gr/cm^3, dhe dendësi më të madhe e kanë dunitet e freskët, σ = 2,7 – 3,3 gr/cm^3. Në kurbat e variacionit (shih fig. 2) vihet re se kurba e variacionit të duniteve ka formë asimetrike, gjë që vërteton shkallën e ndryshme të serpentinizimit të shkëmbinjve [7].

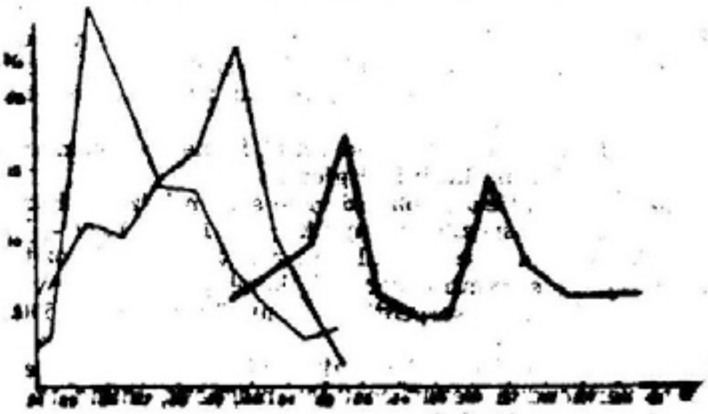

Fig. 2. Kurbat e variacionit të shkëmbinjve dhe xeherorit të kromit [1].
1- Dunite; 2- Peridotite; 3- Kromit

Dunitet larakterizohen nga rezistencë elektrike specifike më të lartë (ρ = 2280 – 6320 Ohm.m), shih fig. 3. Densiteti i peridotiteve varet gjithashtu nga përbërja mineralogjike dhe shkalla e serpentinizimt. Llojet e peridotitit që përmbajnë më shumë piroksen kanë dendësi 3,0 gr/cm^3. Peridotitet e serpenzinizuar kanë dendësi 2,5 – 2,7 gr/cm^3. Rezistenca elektrike specfike e këtyre shkëmbinjve varion nga 32 – 650 Ohm.m. Piroksenitet kanë predspozitet magnetic që lëkundet nga 0-1000 x 10^{-6} CGSM, kurse gabbro-pegmatitet χ=0 - 150 x 10^{-6} CGSM. Vlerat e larta të predozitetit në piroksenitet shpjegohen me përmbajtje e lartë të magnetitit në to. Dendësia e pirokseneve lëkundet në kufinjtë 3,10 – 3,25 gr/cm

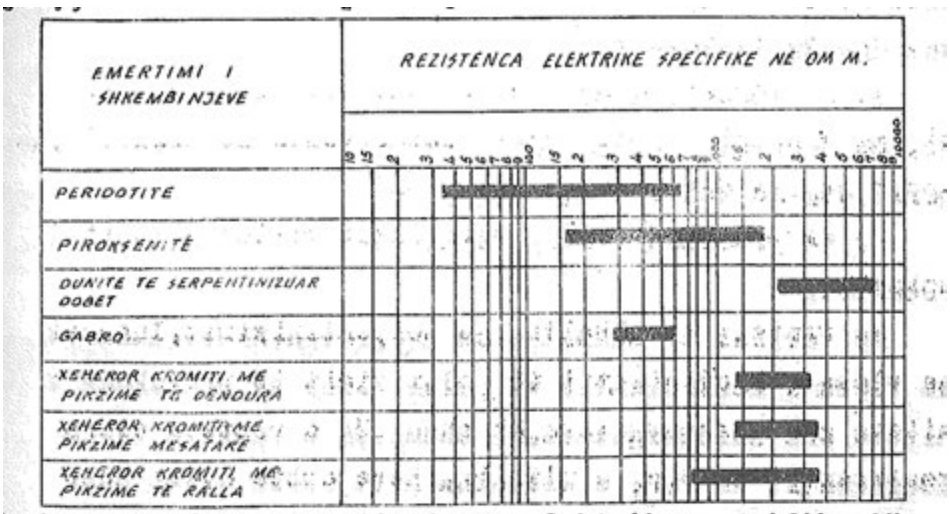

Fig. 3. Rezistenca elektrike specifike e shkëmbinjve dhe xeherorit të kromit [1]

Rezistenca elektrike specifike varion në ρ =162 – 1794 Ohm.m. Xeherori i kromit në përgjithësi ka predspozitet magnetik të ulët χ=(0 – 300 – 500) x 10^{-6} CGSM.

Vetëm për xeherorët me pikëzime që janë nënshtruar veprimeve të fuqishme dinamike, predspoziteti arrin deri $3000*10^{-6}$ CGSM. Në këtë rast, reformimi i magnetitit në masën kryesore të serpentinitit është arësyeja e rritjes së predspozitetit. Në xeherorët massive të zonave, që u janë nënshtruar një veprimi të tillë dinamik, si rezultat i përmbajtjes së vogël të magnetit në masën kryesore, predspoziteti është më i vogël.

Dendesia e kromiteve kondicionohet kryesisht nga pëmbajtja e Cr_2O_3 dhe më tepër nga shkalla e serpentinizumt të komponenteve të tjerë mineralogjike. Kështu dendësia e tyre lëviz në kufinj shumë të gjerë nga 2,56 – 4,27 gr/cm³ (zakonisht nga 2,56 – 3,44 gr/cm³).

Rezistenca specifike elektrike e kromiteve është shumë e lartë dhe varion nga ρ = 730 – 3540 Ohm.m. Ky variacion lidhet me përmbajjen e ndryshme të ujit, çarshmërisë dhe pothuajse nuk varet nga lloji i xeherorit dhe përmbajja e Cr_2O_3.

3. ANALIZA E PUNIMEVE MAGNETOMETRIKE, GRAVIMETRIKE DHE REZULTATET E TYRE

Siç u tregua më lart, në vitin 1957 u kryen për herë të parë punime eksperimentale manjetometrike në shumë objekte. Këto punime u kryen në shkallën 1:2000. Rrjeti i rilevimit ishte 2,5 x 20 m. U përcaktua komponenti vertikal i fushës magnetike Z, matjet u kryen me ndihmën e magnetometrit të tipit Fonsenlau. Gjatë punës, gabimi mesatar kuadratik ishte m=10 γ. Siç duket, saktësia e punimeve është e lartë, rrjeti i përdorur plotësoi kërkesën, që gjatë profilit mbi trup të vendosen mbi 5 pika vrojtimi dhe çdo trup gjatë shtrirjes të ndërpritet nga më shuë se 3 profile.
Siç duket në fig. 4, mbi trup nuk ekziston anomali e komponentit vertikal të fushës magnetike. Edhe një sërë anomalish të verifikuara me punime minerare, nuk u lidhën me ekzistenën e xeherorit. Në disa objekte të veçanta u fituan anomali jo intensive.

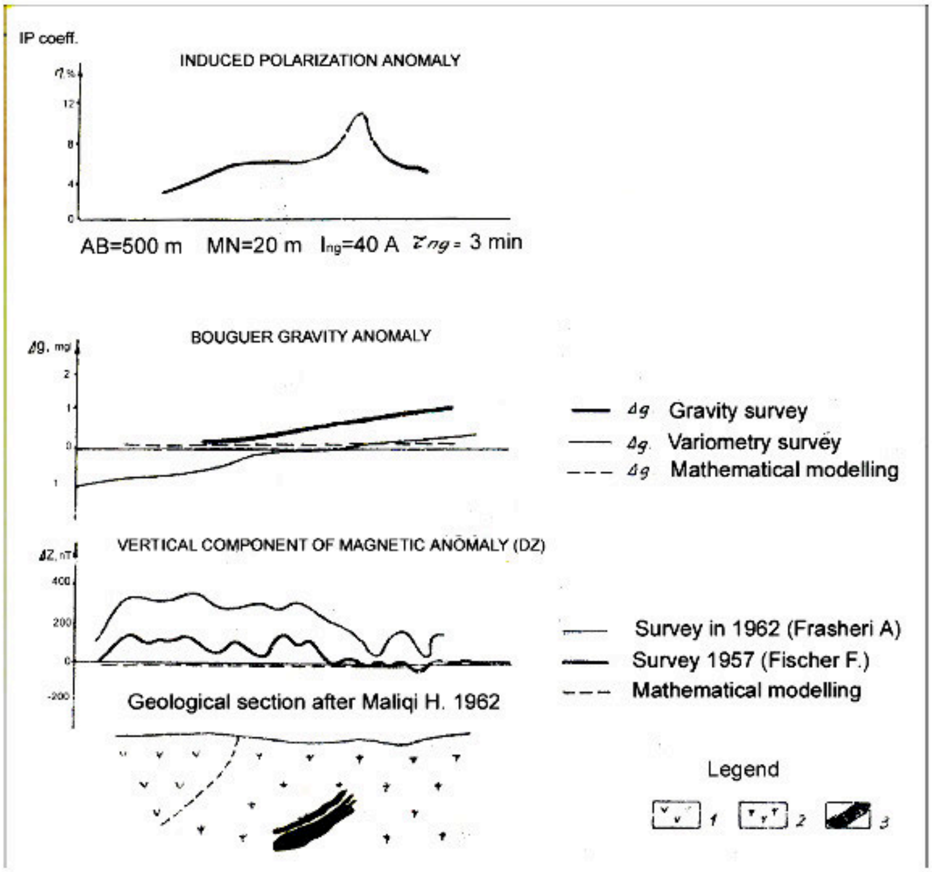

Fig. 4. Prerja gjeologo-gjeofizike e vendburimit "N"

1- Peridotites;
2- 2- dunites;
3- Trupi xeheror
4- i kromiteve.

Pra , në përgjithësi rezultati i punimeve magnetometrike të vitit 1957 ishte negativ, lidhur me dhënien e zonave minerake dhe të trupave qorrë. Po kështu nuk u bë e mundëshme ndarja e veçimeve të duniteve nga peridotitët. Ky rezultat negativ lidhet me një sërë faktorësh objektivë.

a) Predspoziteti magnetic i shkëmbinjve varion në kufi të gjerë dhe shkëmbinjtë e ndryshëm kanë predspozitet të afërt me njëri tjetrin (shih fig. 1) Kjo bën të vështirë dhë në shumë raste të pamundur veçimin e llojeve të ndryshme të shkëmbinjve utrabazikë.

b) Trupat e kromitit, megjithëse kanë predspozitet pak më të ulët se dunitet, kanë dimensione të vogla në krahasim me thellësinë e shrirjes së tyre në këtë mënyrë anomalia e krijuar nga ata, në përgjithësi është e dobët. Këtë fakt e vërteton kalkulimi terik i kurbës së komponentit vertikal të fushës magnetike për trupin xeheror, që rrëfehet është 30,0 gama.

Po kështu shliret dhe dajkat e pirokseneve dhe dajkat e gabropegmatiteve, duke patur këtë predpozitet të ukët (të ngjajshëm me të kromiteve) mund të japing anomali, që të kondicionohen si anomali të dhëna nga kromitet. Kjo gjë bën të pamundur zgjidhjrn e njëanëshme të anomalive "negative" të vogla të trupave ekzistues.

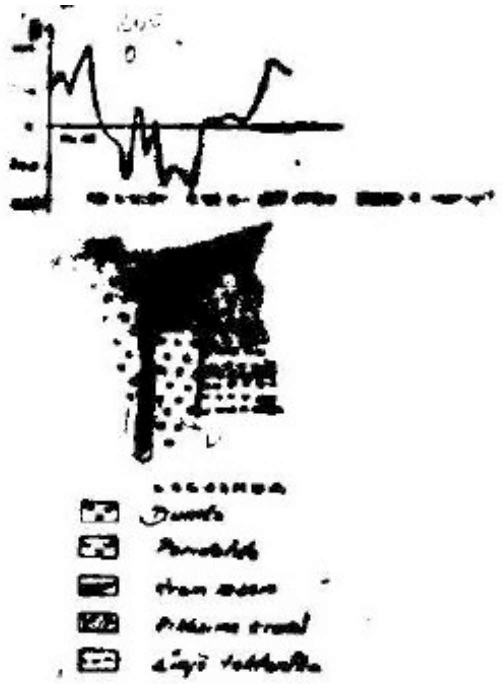

Fig. 5. Preje gjeologo-gjeofizike e vebdurimit "A" të kromit. Kurba e komponentit të fushës magnetike (Punimet e vitit 1962).

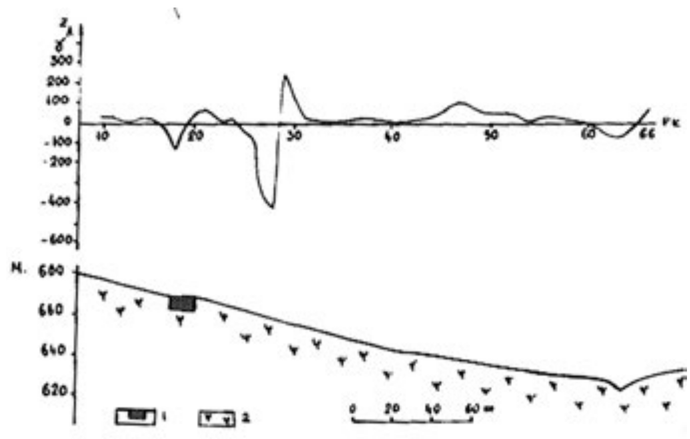

Fig. 6. Grafiku i komponentit vertikal të të fushës magnetike në rajonin19 "K" e punimeve të vitit 1962.

c) Relievi i aksidentuar ul në maksimum efektivitetin e kësaj metode. Megjithë rezultatet negative, në vitin 1962, mbase u gjetën objekte të pa përshtatshëm, u kryen përsëri punime magnetomerike. Këto punime u kryen në shkallën 1:2000, u përdor rrjet vrojtimesh (2,5 – 5) x 20 m. U vrojtua komponenti vertical i fushës magnetike, matjet u kryen me magnetometra M2. Ukryen matje me përpikmëri të lartë, kështu gabimi mesatar i kuadratuar për një objekt ishte m= 3 γ, kurse për një tjetër 7 γ. Si rezultat i interpreitmit të këtyre të dhënave vihet re, që në disa objekte ka anomali "negative" intensive të komponentit vertikal të fushës

magnetike, në të cilat amplitude e anomalisë varion në -600 deri -700 γ (shih fig. 5 dhe fig. 6), kurse në një profik të njërit prej ojekteve të rilevuar gjatë vitit 1957, u muar i njejti rezultat si edhe në vitin 1957 (shih fig. 4) dhe mbi trup nuk fiksua anomali.

Duke mos patur mundësi për të kryer analiza të vetive magnetike të shkëmbinjve dhe të trupit xeheror, që tregohet në fig. 6, po shfrytëzojmë të dhënat e studimt petrografik dhe analizën kimike për të shpjeguar rezltatet e mësipërme.

Analiza kimike tregoi se xeherori i trupit i treguar në fig. 4, përfaqësohet nga kromshpinelit me përmbajtje Cr_2O_3 44,34 % – 17,6 %, FeO 15% - 15,2%. Raporti Cr_2O_3 : FeO është 2,4; Al_2O_3 përmban 5,42% - 13,45%, TiO_2 o,29% - 0,54%, ndërsa trupi i treguar në fig. 6 përfaqësohet nga kromshinelit me përmbajtje Cr_2O_3 45,46 % – 51,72 %. Raporti Cr_2O_3 : FeO është 2,5 – 2,8; Al_2O_3 përmban 4,44% - 7,3%, ka gjurma TiO_2 .

Sipas studimeve petrografike, shkëmbintë dhe trupi xeheror i treguar në fig. 4 janë respektivisht të serpentizizuar dhe shndërruar. Dunitet dhe peridotitet janë kthyer në serpentinit apoduntik dhe apoperidotit. Në shkëmbinjtë, se rezultat i serpentinizimit është formuar magnetit sekondar i cili rrit predspozitetin e tyre.

Shkalla e magnetizmit të xeheroror është pothuajse e plorë, vetëm në vende të holluata të shlifit vërehen gjurmët e minerait primar kromit. Shkalla e shndërrimit të kromshpinelit është gati e njejtë si për shkëmbinjtë ashtu edhe xeherorin. Përqindja e lartë e përmbajtjes së hekurit në xeheror, kryesisht në formën e magnetitit (Cr_2O_3:FeO = 2,4), shkalla e njejtë e shndërrimit të shkëmbinjve dhe xeherorit, mendojmë se solli që predspoiteti magnetik i tyre dallohet fare pak. Kështu mbi trupin (fig. 4) nuk merret anomaly e komponentit vertikal të fushës magnetike.

Xeherori i trupi që tregohet në fig. 5 është pjesërisht i shndërruar (magnetizuar) e kryesosht sipas çarjeve, periferitë e të cilave paraqesin plotësisht anë të shndërruara. Magnetiti ndodhet në formën e damarrëve në pjesët e dobëta të kokrruzës.

Shkalla e shdërrimit (magnetizimit) të shkëmbnjve rrethues është më i theksuar se në trupin xeheror, aty magnetizimi është i plotë. Këto faktorë si edhe përmbajja më e vogël e hekurit në xeheror, të fig. 6-të sa në trupin e treguar në fig. 4, mendojmë se ka shkaktuar, që mbi trupin xeheror të merret anomali negative e komponentit vertikal të fushës magnetike.

Kjo gjë vërteton edhe një herë konluzionin e arritur nga specialistët gjeofizikë, që mbi trupat e kromitit mund të merren anomali të fushës magnetike [7], por këto anomaly nuk takohen kudo. Ato fitohen në ato objekte ku dimensionet e trupit xeheror janë të konsiderushme në kahasim me thellësinë e shtrirjes së tyre, relieve i përshtatshëm, predpoziteti magnetic i dallueshëm në mes shkëmbinjve dhe xeherorirt.

Vlen të theksohet influenca negative e madhe e relievit në rezulatet e magnetometrisë. Relievi i aksidentuar e deformon dhe e bën jo të qetë fushën magnetike. Mjafton vetëm një përrua i thellë 4-5m për të krijuar anomali analoge me ato që krijohen mbi trupin e kromitit, kjo gjë vihet re qartë në fig. 6. Të gjithë këta faktorë objektivë negativë ulit efektivitetin e metodës së magnetometrisë për kërkimie trupave qorrë të kromit dhe e bëjnë atë të përdorshëm vetëm në raste të veçanta, të përshtatshme.

Ne vitin 1958-1979 në këto objekte u kryen punime gravimetrike. Rrjeti i vrojtimit ishte 20 x 40 m. Kjo lejoi që kryq shtrirjes së trupit të vendoseshin mbi tre pika vrojtimi dhe, gjatë shtrirjes trupi të intersektohej nga të paktën 3 profile. Vrojtimet u kryen me gravimerin GAK-3M dhe variomerin e firmës Etvesh, Përpiksmëria e punimeve ishte e mirë, gabimi mesatar i kuadratuar ishte 0,08 mgl.

Megjithë këtë ndërtimi gjeologjik i vendbrimeve nuk u pasqyrua në shpërndarjen e forcës së gravitetit. Trupat xeherorë pothuajse nuk ndihuan fare në rezultatet e matjes. Kjo gjë dukët qartë në fig 4.

Këto rezultate negative lidhen ne arësyet e mëposhtëme:

a) Trupat xeherorë kanë dimensione të vogla në raport me thellësinë e vendosjes së tyre. Pra, akseleracioni i forcës së gravitetit, i krijuar nga kjo masë është i vogël. Ko tregon se me aparaturën e përdorur dhe saktësinë e arritur, këto anomali nuk mund të fiksoheshin.
b) Densiteti i shkëmbinjve rrethues (σ =2,66 gr/cm^3) varion në kufin të gjeë dhe janë të afërt me njeri tjetrin.

Kalkulimet teorike të forcës së gravitetit, vërtetuan këto konkluzione. Në fig, 4 tregohet kurba teorike e Δg për trupin e kromitit, që i është nënshtruar studimit. Vlera maksinale e Δg mbi trupin e dhënë është 0,016 mgl.

Polarizimi i provokuar dhe rezultatet e kësaj metode

Gjatë dhjetë viteve të fundit është rritur mjaft interesimi për përdorimin e matjeve elektrike, të njohura me emërtimin e polarizimit të provokuar. Mendohet se gjatë kalimit të rrymës elektrike nëpër zonën xeheroe, lindin në përgjithësi të njejtat fenomene si edhe gjatë polarizimit të elektrodave.

Metoda e polarizimit të provokuar u përdor në përgjithësi për verifikimin e anomalive të potencilit natyral dhe profilimeve e kombinuara mbi trupat xeherorë sulfidë, për dallimin e këtyre anomalive nga "anomali" të rreme që mnd të lindin në zonat e kontakteve tektonike dhe nga lëvizjet e ujërave nëntokësore, fig. 7 [1,9].

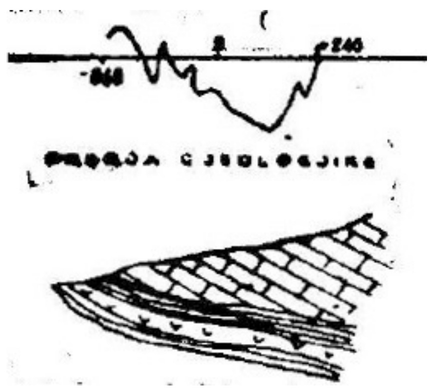

Fig. 7. Grafiku i potencialit të fushës elektrike natyrale për rajonin "B". Potenciali negative mund të lidhet ose me ekzistemcën e xeherorizimit sulfur ose me gëlqerorët [1].

Përpunimi i metodës së polarizimit të provokuar është bërë në dy drejtime. Në B.R.S.S. është përdorur rryma e vazhduar, kurse në shtetet e perëndimit janë përdorur impulse të rrymës së vazhduar me period të shkurtër dhe rryma alternative (sinusoidale). Në vendin tonë është përdorur deri tani rryma e vazduar.

Teoria e metodës së potencialit të polarizimit të provokuar është e përpunuar shumë pak. Edhe për variantin më të thjeshtë dhe më të përhapur të metodës së polarizimit të provokuar, në të cilën rryma polarizuese është rryma e vazhduar, mbetet akoma teorikisht e pa studiuar.

Punimet jo të shumta [3, 5, 11, 12, 13, 14, 19, 20, 21, 23] që janë botuar në kohën e sotme kanë karakter diskutimi, për më tepër në disa nga këto punime tregohet principalisht pamundësia e përdorimit të kësaj metode [22].

Janë bërë përpjekje për kalkulimin teorik të fushave

Të polarizimit të provokuar të trupave në formën të thjeshtë gjeoemtrike [5, 11]. Punime eksperimentae më metodn e polarizimit të provokuar tëk ne janë bërë ne vitin 1960 dhe 1962 në vendburimet e bakrit, në pjesën veriore të Shqipërisë [18].

Rezultatet e këtyre punimeve me metodat e potencialit natyral, profilimet e kombinuara dhe polarizimin e provokuar, paraqiten në fig. 8.

Qëllimi i ynë në këtë punim nuk është analiza e këtyre rezultateve, prandaj po kufizohemi vetëm me përmendjen e tyre.

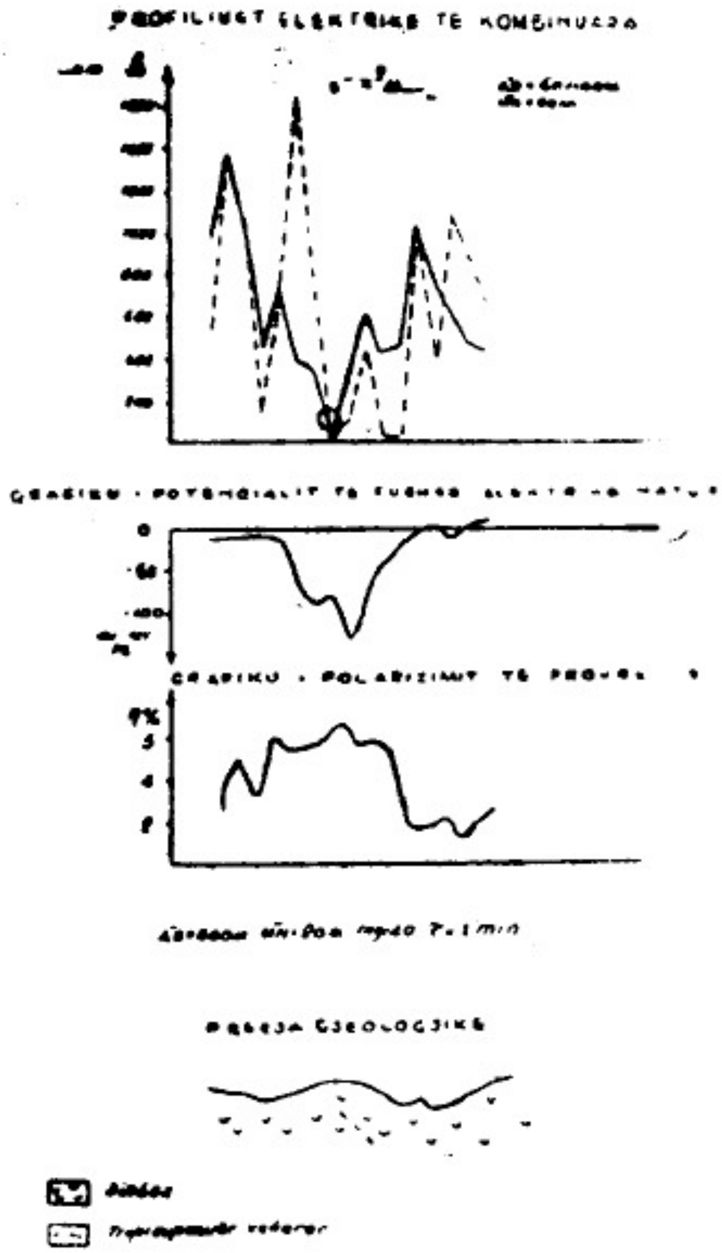

Fig. 8. Profili gjeologo-gjeofizik në rajonin “L” e punimeve të vitit 1962, për kërkimin e sulfideve ë bakrit.

Zbatimi i metodë së polarizimit të provokuar, në gjetjen e mineralizimit sulfide nuk është kaq i thjeshtë, si mund të duket nga sa thamë më lart. Një nga arsyet është se edhe minerale e tjerë gjysëm përçues, si graffiti dhe piroluziti, japing efekte të ngjajshme të polarizimit të provokuar. Nga një gerë efektin e polarizimit të provokuar mund ta vërejmë edhe atje ku mungojnë mineralet gjysmë përçues.

Është përcaktiar se materialet që polarizohen ruajnë për një farë kohe ngarkesën elektrike dhe pasi ndërpritet dërgimi i rrymës elektrike. Në esencë, fenomeni që vrojtohet paraqet në vetvehte gradientin e tensionit, por kjo gjë akoma nuk do të thotë se në të vërtetë kjo është ngarkesë elektrike, në fakt do të ketë vend një farë rrjedhje. Efekti i polarizimit të provokuar mund të konsiderohet si grumbullim të energjisë në materialet gjatë kalimit të rrymës dhe që zakonisht një pjesë e saj çlirohet nën e veprimin e ngarjesës pas stakimit të rrymës [5]. Ekzistojnë pesë lloje të grumbullmit të energjsë elektrike, magnetike, mekanike, termike dhe kinike. Ka mundësi që në plarizimin e provokuar të marrin pjesë të gjitha llojet e enerjgjisë [5]

Grumbullimi i energjisë elekrike dhe kimike janë format më të tjeshta të efektit të polarizimit të provokuar, që lidhen direkt me mineralet perçuese dhe që janë të ngjajshëm me polarizimin e elektrodave. Pikërisht, ky efekt i polarizimit të provokuar, përdoret për kërkimin e mineraleve sulfide të bakrit.

Tjetër formë e grumbullimi të energjisë është grumbullimi i energjisë të fushës magnetike. Është e njohur, se rryma elektrike gjithëmon formon fushën magnetike dhe kur ndërpritet rryma, fusha magnetike që dobësohet kthen energjinë e grumbulluar në formën e energjisë elektrike. Ky efekt mund të jetë shumë i komplikuar nëqoftëse gjeometria e rrjedhjes së rrymës nuk është e rregullt, por për format e thjeshta të gjysmë hapësirës ka zgjidhje të mira dhe të thjeshta [5]. Nëqoftë se në punimet fushore përdoren skemat, në të cilat elektrodat vendosen gjatë një vije të drejtë, atëhere efektet elektromagnetike nga pikëpamja cilësore janë të ngjajshëm me efektet e polarizimit në zonat menerale [5].

Format e tjera të grmbullmit të energjisë kanë lidhje me fenomenet elektromagnetike, termoelektrike, të difuzionit dhe të polarizmit membranor. Këto forma përshkruhen mjaft mirë në punimin e D.J.Marshall dheTh. R. Madden.

Polarizimi i provokuar në kromite, mendojmë se ka ldhje me grumbullimin e energjisë elektrike dhe kimike, me prezencën e magnetitit, që rrethon në formën e cipave kokrrizat e kromitit (shih fig. 8), me ekzistencën e limonitit në disa kromite, në formën e brezave të hollë, ku mundet të ndodhë gumbullimi i energjisë nën veprimin e presioneve osmotike. Mund të inlfuencojnë edhe format e jera të grumbullimit të energjisë.

Punimet elektometrike u kryen në dy faza, në laborator dhe në fushë. Punimet laboratorike kishin për qëllim përpunimin e metodikës së vrojtimit dhe verifikimin e rezulateve të arritura me këtë metodë për trupa përçues nga studiuesit e huaj.

Punimet fushore u kryen mbi një trup të kromitit, forma e të cilit është përcaktuar plotësisht nga punimet minerare.

Vrojtimet u kryen duke matur gradientin e potencialit më anën e skemës së gradientit të mesëm AMNB. Distanca AB=500 m, MN=20 m, hapi 10 m.

Rryma e ngarkesës ishte 4 Amper, kurse koha, që lejohej kjo rrymë të shkonte të tokë ishtë 5 minuta.

Këto parametra u zgjodhën në mënyrë eksperimentale. Për këtë, duke mbajtur rrymën e ngarkesës I_{ng}= 2 Amper, koha e ngarkesës u muar 2, 4, 6, 8, 10, 15 dhe 20 minuta.

Për të caktuar rrymën e ngakesës duke mbajtur konstant kohën e ngarkesës (τ) i provou bë ngarkimi me 1, 2, 3, 4, 5 dhe 6 Amper. Siç duket nga fig. 9, potenciali i provokuar në shkëmbinjtë ultrabazikë, në varësi të rrymës së ngarkesës rritet pothuajse në formë lineare. Polarizimi i provokuar rri në përgjithësi constant dhe fillon të rritet pak, vetëm mbas I = 5 Amper.

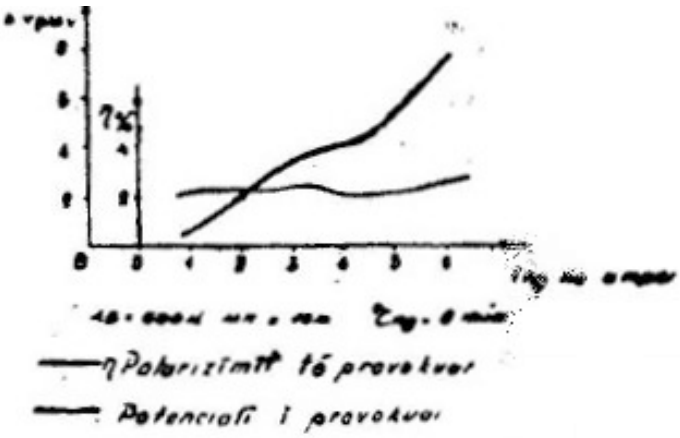

Fig. 9. Varësia e potencialit dhe polarizimit të provokuar nga rrymë e ngarkesës për shkëmbinjtë ultrabazikë.

Gjatë këtyre eksperimenteve u vu re një fenomen i tillë: kur rryma e ngarkesës ishte mbi 2 Amper, mbas kohën 5-6 minuta, rryma në qarkun ushqyes zvogëlohej; mbas 10-12 minutash vlera e saj arrinte ne 50% të vlerës fillestare të rrymës. Ky fenomen vërehej më tepër në ditët e nxehta, kur toka ishte shumë e thatë. Mbas lagies së vendit të tokëzimit të elektroave AB, në fenomen i tillë nuk vërehej.

Rrënia relativisht e shpejtë e rrymës në qarkun ushqyes lidhet me krijimin e ndonjë cipe me përçueshmërielektrike të keqe, në tokëzimin që lidhet me anodën e burimit ushqyes dhe afër tij. Gjatë ndërrimit të dejtimit të rrymës, kjo cipë shkatërrohej në anodën e vjetër dhe krijohej në anodën e re, por për këtë kërkohen përsëri një farë kohe.

Si rezultat i kërtyre eksperimenteve, u bë e mundur të theksohen disa faktorë, të cilët përcaktojnë vlerën e polarizimit të provokuar në shkëmbinjtë ultrabazikë:

1) Varësia e polarizimit të provokuar nga koha e ngarjesës është e theksuar dhe ka formë të konplikuar. Koha që do të jepte një polarizim të provokuar të madh është mbas 10 minutash ngarkese. Por në këtë rast, do të ndodhë polarizim i theksuar i elektrodave të qarkut ushqyes, për të cilën u bë fjalë më sipër dhe e elektrodave të qarkut marrës. Pra koha më e përshtatshme e ngarkesës është 4-8 minuta.

Shënim: "Mungon faqja në vazhdim, në kopjen e vetme të këtij artikulli që ruhet.

Në fig. 4 dhe 10 jëpët kurba e koeficientit të polarizimit të provokuar mbi trupin e njohur të kromitit. Larg trupit xeheror, polarizimi i provokuar merr vlerën η=3,2%. Në zonën afër trupit xeheror dhe mbi të rritet vlera e polarizimit deri 5-6%. Mbi pjesën e sipërme të trupit η=10,8%. Mendojmë se kjo rritje e thekrusar e polarizimit të lidhet me influencën e pjesës së sipërme të trupit, e cila është më afër sipërfaqes.

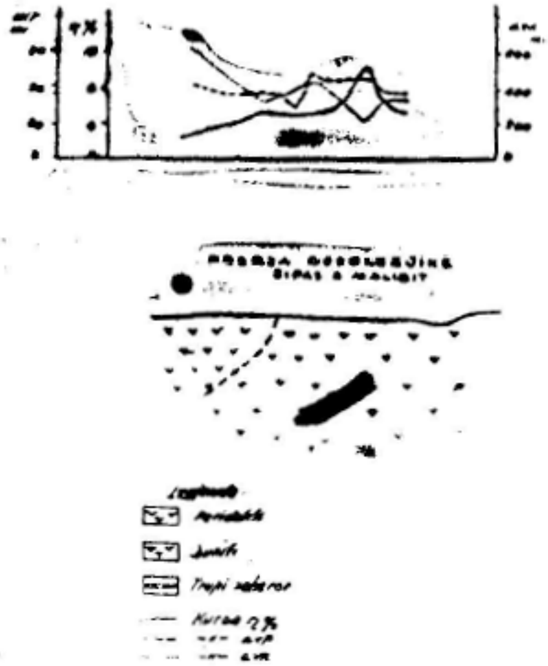

Fig. 10. Grafikët e potencialit të polarizimit të provokuar dhe potencialit kalimtar në vendburimin e kromit “N”.

Kështu, mbi truin xeheror fiksohet një anomali e polarizimit të provokuar me amplitudë mesatarisht 2-2,5 % më tepër se sfondi i përgjithshëm.

Pra, punimet e vitit 1962 dhanë rezultate positive me këtë metodë. Me gjithë këtë, vlen të theksohet se këto punime janë kryer në një objekt. Në të ardhmen duhet ët intensifikohen këto punime. Vetëm në këtë mënyrë do të përpunohet metodika fushore dhe e interpretimit, e cila edhe jashtë shtetit është në këtë fazë eksperimentale dhe do të arrihen konkluzione të plota mbi efektivitetin e kësaj metode për kërkimin e kromiteve.

Konkluzione

Punimet gjeofizike të vendosura në kromitet deri në kohën e sotme, kanë dhënë rezultate të ndryshme për objektet e studiuar. Ka patur rezultate negative dhe positive. Duke u mbështetur në analizën e dhënë më lart kemi arritur këto përfundime:

1) Jo në të gjithë objektet do të fiksohet anomali e fushës magnetike dhe e gravitacionit. Të tilla anomali do të merren në ato vendburime ku trupat xeherorë kanë dimensione të konsiderueshme në lidhje me thellësinë e vendosjes së tyre, shkëmbinjtë dhe xeherorët të kenë veti fizike (predspozitet magnetik dhe dendësi) të dallueshme nga njëri tjetri.

2) Mbi trupin qorr të kromitit u muar anomalia e polarizimit të provokuar. Kjo gjë hap perspektivën e përdorimit të kësaj metode të re për kërkimin e trupave qorre të kromit.

3) Relievi i aksidentuar ul efektivitetin e punimeve gjepfizike. Ai shkakton deformimin dhe bërjen jo të qetë të fushave magnetike, të gravitacionit dhe elektrike.

Në përfundim të këtij punimi, duke u bazuar në rezultatet e arritura deri më sot, mbi përdrimin e metodave gjeofizike për kërkimin e trupave qorre të kromitieve, për të ardhmen rekomandojmë:

1) Të vazhdojnë punimet eksperimentale me metodën e polarizimit të provokuar. Për këtë duhen kryer eksperimentet në disa objekte në kushte të ndryshme të vendosjes së trupit xeheror, formës, dimensioneve dhe përbërje mineralogjikë të ndryshme, etj. Duhen vazhduar punimet laboratorike. Për të kryer punimet fushore dhe laboratorike është e domosdoshmë që aparatura ekzistuese të modifikohet dhe të aplikohet për këtë metodë, pa i ndëruar parametrat e saj në metodat e tjera.

2) Punimet magnetometrike në koordinim me punimet gravimerike mund të vendosen vetëm në disa objekte të përshtatshëm. Për këtë kërkohet, që relieve të jetë i sheshtë, i kategoisë së II-të dhe të III-të, mikrorelievi të jetë i qetë, trupat xeherorë të kenë dimentisone të konsiderueshëm në raport me thellësinë e vendosjes së tyre.

3) Për të kryer punimet fushore me këtë metodë është e domosdoshme që matjet të kryhen me aparate preçizioni, magnetometra që kanë vlerën e ndarjes rreth 10 gama dhe gravimetra që kanë saktësinë 0,05-0,01 mgl.

4) Të fillojmë studimet laboratorike petromagnetike për të njohur sa më mirë vetitë fizike të shkëmbinjve, e cila është konditë kryesore dhe e domodoshme në interpretimin e të dhënave fushore.

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Shënim: "Mungon faqja e fundit e artikullit, me referencat 11 deri , në kopjen e vetme të këtij artikulli që ruhet.

Më poshtë po bashkangjitet origjinali i fotokopjuar i këtij artikulli që ruhet deri me sito. Siç duket në këtë kopje, disa figurat janë të një cilësie jo të mirë, si pasojë e teknikës kopjuese të kohës.

'Studime gjeologjike" vol III, Botim USHT, Fak gjeol. min. Tiranë 1966

APLIKIMI I METODAVE TË REJA GJEOFIZIKE PËR KËRKIMIN E TRUPAVE TË KROMITEVE NË PJESËN VERIORE TË SHQIPËRISË

LIGOR LUBONJA — ALFRED FRASHËRI

Katedra e vendburimeve

Për kërkimin e trupave qorre të kromiteve në vendin tonë, janë kryer gjatë viteve 1957/59 punime manjetometrike dhe gravimetrike, rezultatet e të cilave në përgjithësi kanë qënë negative. Këto punime u kryen nga ekspeditat e Komitetit Shtetëror të Gjeologjisë.

Duke patur parasysh detyrat e ditës në kërkimin e kromiteve, në vitin 1962 u përdor përsëri metoda e manjetometrisë dhe u eksperimentua për herë të parë metoda e re e polarizimit të provokuar. Këto punime u kryen nga ekspedita gjeofizike e Ndërmarjes Gjeologo-topografike në bashkëpunim me laboratorin e gjeofizikës të Universitetit Shtetëror të Tiranës.

Në këtë artikull jepen analiza e punimeve të viteve 1957/59 dhe rezultatet e punimeve të vitit 1962.

1. — NDËRTIMI GJEOLOGO-PETROGRAFIK I TRUPAVE DHE ZONAVE MINERALE

Shkëmbijtë që ndërtojnë vend burimet e kromiteve, përfaqësohen nga kompleksi intruziv i shkëmbijve ultrabazikë. Dunitet janë shkëmbijtë kryesorë që përmbajnë kromitin dhe takohen në formë veçimesh në masën e peridotitëve.

Kontakti i duniteve me serpentinitet apoperidotit në përgjithësi është gradual, megjithëse kemi raste kur kontaktet janë të qartë. Strukturat primare të shkëmbinjve shumë herë janë prishur krejtësisht, s rezultat i zhvillimit intensiv dhe të plotë të proçesit të serpentinizimi proçes i cili në disa raste sjell formimin e makrostrukturave rjetore. N përgjithësi, përbërja minerallogjike është e thjeshtë dhe në të shumt e rasteve është e qëndrueshme.

Duke studjuar përbërjen minerallogjike të duniteve vihet re zh llimi i madh i serpentinës prej olivine, si përbërës kryesor i shkëmb Si minerale sekondare takohen brucit dhe minerale metalorë (magne në formë pluhuri). Përhapje shumë të madhe kanë peridotitet.

Grada e serpentinizimit të tyre është e ndryshme, shpesh herë hen serpentinite apoperidotite. Në përbërjen mineralogjike të k shkëmbenjve bën pjesë serpentina prej olivine, serpentina prej p ni, magnetiti në sasi të vogël dhe kokriza krom-shpineliti 2-3% ridotitet, aty këtu, vërehen shlire dunitesh.

Në vendburimet takohen damarë piroksenitesh, në përbërjen e të cilëve merr pjesë pirokseni rombik dhe monoklin, rrallë takohen edhe dajka gabro-pegmatitesh.

Trupat xeherore përfaqësohen nga kromitet me pikëzime të rralla, mesatare, të dëndura, me teksturë nodulare, brezore deri në kromit masiv. Xeherori përfaqësohet nga kromshpineliti me sasi të ndryshme të olivinit, serpentinit; më e rallë talkut, kloritit, opalit. Nga një herë kristalet e kromitit rrethohen me cipë magnetiti, që ka lindur si rezultat i veprimeve dinamike të fuqishme.

Mineralet xeheror formues, kromshpineliti, ka formë idiomorfe me kristale me formë kuadratesh në prerje dhe rrallë takohen ksenokristale.

Trupat xeherore në përgjithësi kanë formë damarësh dhe lentash me dimensione të ndryshme që shpesh herë variojnë me kufinj të gjerë edhe brenda një trupi. Për shembull, takohen trupa që gjatë rënies zgjaten sa pesë-gjashtë herë potenca e tyre dhe gjatë shtrirjes sa dhjetë pesëmbëdhjetë herë potenca. Trupat kanë shtrirje në përgjithësi V.VP-JJL dhe bien me kënde rënie nga 25° deri në 80°-85°. Gjatë shtrirjes ata lakohen me kënde që variojnë në kufi të gjerë.

Së bashku me trupat xeherore me potencë të madhe takohen edhe apofiza xeherore të ndara nga duniti, që në të shumtën e rasteve janë paralele me trupin xeheror kryesor. Si rregull, me rritjen e potencës së trupave xeherore, zvogëlohet potenca e brezave të dunitit që intersektojnë trupin.

2. VETITË FIZIKE TË SHKËMBENJVE DHE XEHERORIT

Shkëmbentë që ndërtojnë vendburimet e kromiteve u anë nënështruar veprimeve të ndryshme dinamike, si rezultat i të cilave shkëmbenjtë kanë shkallë të ndryshme serpentinizimi dhe të përmbajtjes së magnetitit.

Ky ndryshim ka shkaktuar që vetitë fizike të shkëmbenjve dhe xeherorëve të variojnë në kufinj të gjerë.

Dunitet e serpentizuar dobët deri të serpentinizuar shumë dhe harcburgitet kanë predspozitet manjetik $\chi = 100 \times 10^{-6} \div 1000 \times 10^{-6}$ CGSM (7). Me rritjen e serpentinizimit rritet dhe predspoziteti manjetik. Kështu dunitet e serpentinizuar pak kanë predspozitet $\chi = 150\text{-}10^{-6}$ CGSM, kurse dunitet e serpentizuar shumë kanë $\chi = 500.10^{-6}$ CGSM (shih fig. 1).

Një rol të rëndësishëm ka luajtur përmbajtja primare e magnetit, mjafton të përmëndim vetëm se 0,1% magnetit, mund të kondicionojë një $\chi = 200 \div 300.10^{-6}$ CGSM (7).

Kufijtë mbrenda të cilëve lëkundet madhësia e predspozitetit të serpentiniteve janë spostuar me anën e xlerave të mëdha, kështu predspoziteti për serpentinët prej duniteve varion nga $\chi = 500.10^{-6}$ deri 750.10^{-6} CGSM (7).

Dunitet e serpentinizuar që përmbajnë pikëzime kromiti kanë predspozitet $\chi = 0 \div 350.10^{-6}$ CGSM. Kjo ulje e predspozitetit manjetik 79
mund të lidhet me përmbajtje më të ulët të magnetitit në krahasim me dunitet pa pikëzime. Po kështu, densiteti i duniteve varet nga shkalla e serpentinizimit. Densitetin më të vogël e kanë dunitet e serpentinizuar ($\sigma = 2.0 \div 3,6$ gr/cm^3) dhe densitet më të madh kanë duni...

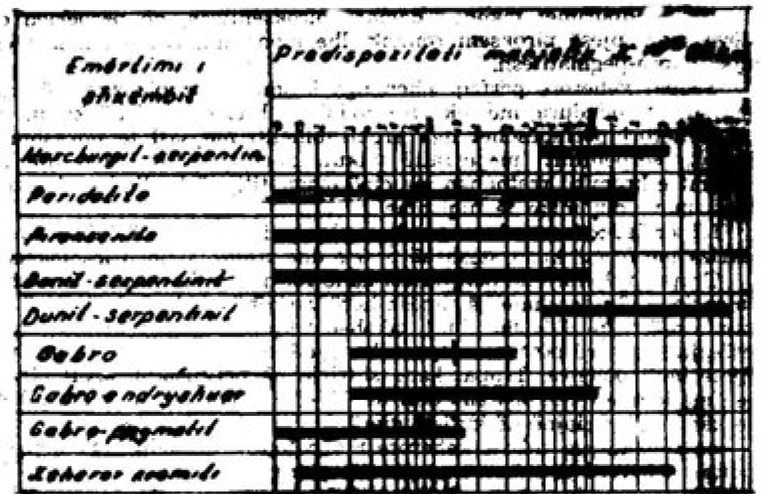

Fig. 1. Predispoziteti magnetik i shkëmbinjve ultrabazikë, bazikë dhe të xeherorit të kromit (7).

freskët (σ = 2,7 ÷ 3,3 gr/cm^3). Në kurbat e variacionit (shif fig. 3) vihet re se kurba e variacionit të duniteve ka formë asimetrike, gjë që vërteton shkallën e ndryshme të serpentinizimit të shkëmbenjve (17).

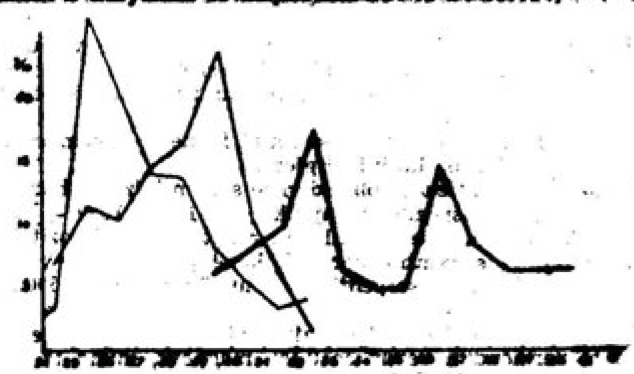

Fig. 3 Kurbat e variacionit të densitetit të shkëmbinjve dhe xeherorit të kromit (1).

——— Dunite ——— Peridotite ——— Kromit

Dunitet karakterizohen nga një rezistencë specifike elektrike më të lartë (ρ = 2280 ÷ 6320 om. m) shif fig. 3.

Densiteti i peridiotiteve varet gjithashtu nga përbërja minerale dhe shkalla e serpentinizimit. Llojet e peridiotitit që përmbajnë piroksen kanë densitet 3.0 gr/cm^3. Peridiotitet e serpentinizuara kanë densitet 2.5 ÷ 2.7 gr./cm^3. Rezistenca elektrike specifike e ty shkëmbenjve varion nga 32 ÷ 650 om.m.

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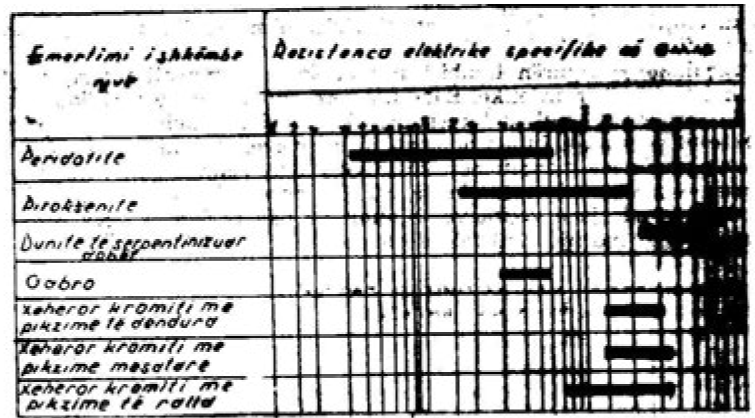

Fig. 3 Rezistenca elektrike specifike e shkëmbinjve dhe xeherorit të kromit (1).

Piroksenitet kanë predspozitet manjetik që lëkundet nga 0 ÷ 1000.10 $^{-6}$ CGSM, kurse gabro-pegmatitet $\chi = 0 \div 150.10^{-6}$ CFSM. Vlerat e larta të predspozitetit në piroksenitet shpjegohet me përmbajtjen e lartë të magnetitit në to. Densiteti i piroksenitëve lëkundet në kufijtë 3.10 ÷ 3.25 gr./cm³.

Rezistenca elektrike specifike varion në $\rho = 162 \div 1794$ om. m.

Xeheror i kromitit në përgjithësi ka predspozitet manjetik të ulët $\chi = 0 \div 300 \div 500.10^{-6}$ CGSM. Vetëm për xeheroret me pikëzime që u janë nënshtruar veprimeve të fuqishme dinamike, predspoziteti arrin deri 3000.10 $^{-6}$ CGSM. Në këtë rast riformimi i magnetitit në masën kryesore të serpentinitit është arësyeja e rritjes së predspozitetit. Në xeherorët masive të zonave, që u janë nënshtruar një veprimi të tillë dinamik, si rezultat i përmbajtjes së vogël të magnetitit në masën kryesore, predspoziteti është më i vogël.

Densiteti i kromiteve kondicionohet kryesisht nga përmbajtja e Cr_2O_3 dhe më pak nga shkalla e serpentinizimit të komponenteve të tjerë minerallogjikë. Kështu densiteti i tyre lëviz në kufi shumë të gjerë nga 2.85 ÷ 4.27 gr./cm³ (zakonisht nga 3.06 ÷ 3.44 gr./cm³).

Rezistenca specifike elektrike e kromiteve është shumë e lartë dhe varion në ρ = 780 ÷ 3540 om.m. Ky variacion lidhet me përmbajtjen e ndryshme të ujit, gurthmërinë dhe pothuajse nuk varet nga lloji i xeherorit dhe përmbajtja e Cr_2O_3 në të.

3. ANALIZA E PUNIMEVE MANJETOMETRIKE, GRAVIMETRIKE DHE REZULTATET E TYRE

Siç u tregua më lart, në vitin 1957 u kryen për herë të parë punime eksperimentale manjetometrike në shumë objekte. Këto punime u kryen në shkallën 1 : 2000. Rjeti i rilevimit ishte 2.5 x 20 m. U përcaktua komponenti vertikal i fushës manjetike Z, matjet u kryen me ndihmën e manjetometrit të tipit Fonsenlau. Gjatë punës, gabimi mezatar i kuadratik ishte m = 10 γ. Siç duket, saktësia e punimeve është e lartë, rjeti i përdorur plotësoi kërkesën, që gjatë profilit mbi trup të vendosen mbi

5 pika vrojtimi dhe çdo trup gjatë shtrirjes të ndërpritet nga më shumë se 3 profile.

Siç duket në figurën 4, mbi trup nuk ekziston anomali e komponentes vertikal të fushës manjetike. Edhe një sërë anomalish, të verifikuara me punime minerale, nuk u lidhën me ekzistencën e xeherorit. Në disa objekte të veçanta u fituan anomali jo intensive. Pra, në përgjithësi rezultati i punimeve manjetometrike të vitit 1957 ishte negativ, lidhur me dhënien e zonave minerale dhe të trupave gorre. Po kështu nuk u bë e mundëshme ndarja e veçimeve të duniteve nga peridotitet. Ky rezultat negativ lidhet me një sërë faktorësh objektivë:

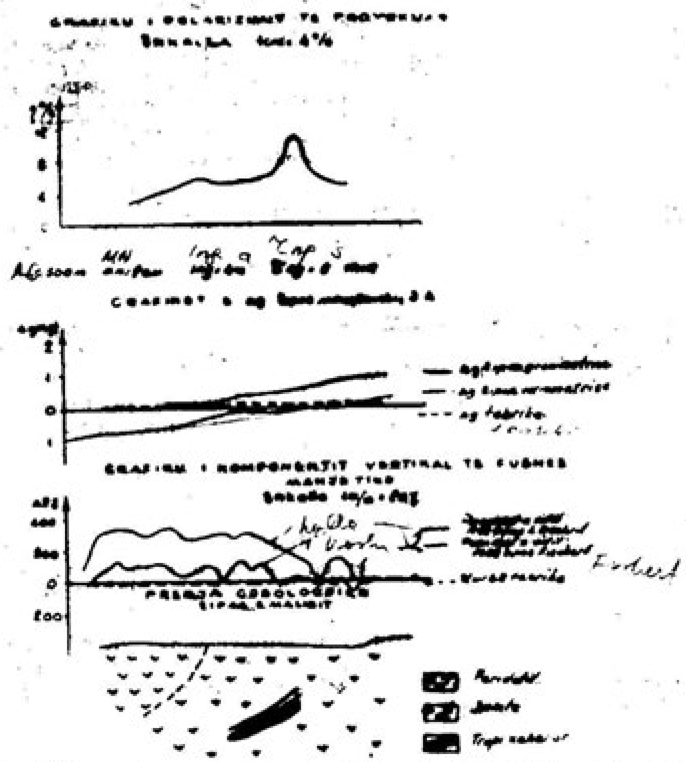

Fig. 4 Prerja gjeologo-gjeofizike e vendburimit «N».

a) Predspoziteti manjetik i shkëmbenjve varion në kufi të gjerë dhe shkëmbenjtë e ndryshëm kanë predspozitet të afërtë njëri me tjetrin (shih fig. 1). Kjo gjë bën të vështirë dhe në shumë raste të pamundur veçimin e llojeve të ndryshme të shkëmbenjve ultrabazike.

b) Trupat e kromitit, megjithëse kanë predspozitet pak më të ulët se dunitet, kanë dimensione të vogla në krahasim me thellësinë e shtrirjes së tyre, në këtë mënyrë anomalia e krijuar nga ata, në përgjithësi është
82 e dobët. Këtë fakt e vërteton kalkulimi teorik i kurbës së komponentit

vertikal të fushës manjetike për trupin xeheror, që rëfehet në fig. 4 (shih fig. 4). Vlera maksimale e komponentit vertikal të fushës manjetike mbi trup është 300 gama.

Po kështu shliret e dajkat e piroksenëve dhe dajkat e gabropegmatiteve, duke pasur këtë predispozitet të ulët (të ngjajshëm me të kromiteve) mund të japin anomali, që të kondicionohen si anomali të dhënë nga kromitet. Kjo gjë bën të pamundur zgjidhjen e njëmendshme të anomalive «negative» të vogla të trupave ekzistues.

c) Relievi i aksidentuar ul në maksimum efektivitetin e kësaj metode. Megjithë rezultatet negative, në vitin 1962, mbasi u gjetën objekte të përshtatëshëm, u kryen përsëri punime manjetometrike. Këto punime u kryen në shkallën 1 : 2000, u përdor rjet vrojtimesh $(2.5 \div 5) \times 20$ m. U vrojtua komponenti vertikal i fushës manjetike, matjet u kryen me manjetometrin M-2. U kryen matje me përpikmëri të lartë, kështu gabimi mezatar i kuadratuar për një objekt ishte $m = 3\ \gamma$ kurse për një tjetër $m = 7\ \gamma$.

Si rezultat i interpretimit të këtyre të dhenave vihet re, që në disa objekte ka anomali «negative» intensive të komponentit vertikal të fushës manjetike, në të cilat amplituda e anomalisë varion në $-600 \div -700\ \gamma$ (shif fig. 5 dhe fig. 6) kurse në një profil të njerit nga objektet të rilevuar gjatë vitit 1957, u muar i njejti rezultat si dhe në vitin 1957 (shif fig. 4) dhe mbi trup nuk u fiksua anomali.

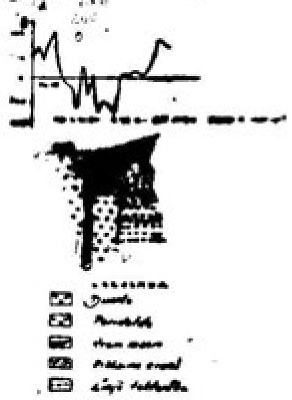

Fig. 5. Prerja gjeologo-gjeofizike e vendburimit «A» të kromit. Kurba e komponentit vertikal të fushës manjetike (Punimet e vitit 1962)

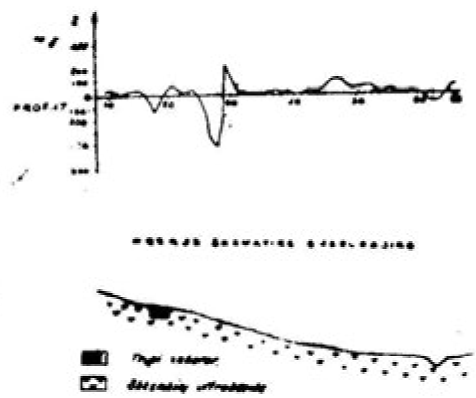

Fig. 6. Grafiku i komponentit vertikal të fushës manjetike në rajonin «K» e punimeve të vitit 1962.

Duke mos patur mundësi për të kryer analiza të vetive manjetike të shkëmbenjve dhe të trupit xeheror, që tregohet në fig. 6, po shfrytëzojmë të dhënat e studimit petrografik dhe analizën kimike për të shpjeguar rezultatet e mësipërme.

Analiza kimike tregoi se xeherori i trupit i treguar në fig. 4, përfaqësohet nga kromshpinelit me përmbajtje Cr_2O_3 $44{,}34 \div 17.8$ FeO
83 15% — 15.2%. Raporti $Cr_2O_3 : FeO = 2.4$; Al_2O_3 përmban 5,42 — 13.45%; TiO_2 0,29 — 0,54%; ndërsa trupi i treguar në fig. 6 përfaqësohet nga

kromshpinelit me përmbajtje Cr_2O_3 40,25 — 51.72%. Raporti Cr_2O_3 : FeO = 2,5 — 2,8; Al_2O_3, përmban 4,44 — 7,3%, ka gjurma TiO_2.

Sipas studimeve petrografike, shkëmbenjtë dhe trupi xeheror i treguar në fig. 4 janë respektivisht serpentinizuar dhe shndruar. Dunitet dhe peridotitet janë kthyer në serpentinit apodunit dhe apoperidotit. Në shkëmbenjtë si rezultat i serpentinizimit është formuar magnetit sekondar i cili rrit predspozitetin e tyre.

Shkalla e magnetizimit të xeherorit është pothuajse e plotë, vetëm në vendet e bollsara të shlifit vërehen gjurmat e mineralit primar kromit. Shkalla e shndrimit të krom shpinelitit është gati e njëjtë si për shkëmbenjtë ashtu dhe xeherorin. Përqindja e lartë e përmbajtjes së hekurit në xeheror, kryesisht në formën e magnetit (Cr_2O_3 : FeO = 2.4), shkalla e njëjtë e shndrrimit të shkëmbenjve dhe xeherorit, mendojmë se solli që predspoziteti manjetik i tyre të dallohet fare pak. Kështu mbi trupin (fig. 4) nuk meret anomali e komponentit vertikal të fushës manjetike.

Xeherori i trupit që tregohet në fig. Nr. 5 është pjesërisht i shndruar (magnetizuar) e kryesisht si mbas çarjeve, periferitë e të cilave paraqesin plotësisht anë të shndruara. Magnetiti ndodhet në formë damarësh në pjesët më të dobëta të kokrizës.

Shkalla e shndrimit (magnetitizimit) të shkëmbenjve rrethore është më e theksuar se në trupin xeheror, aty magnetitizimi është i plotë. Këta faktorë, si dhe përmbajtja më e vogël e hekurit në xeheror, se sa në trupin e treguar (në fig. 4), mendojmë se shkaktuan, që mbi trupin xeheror të fig. 6-të merret anomali negative e komponentit vertikal të fushës manjetike.

Kjo gjë vërteton dhe një herë konkluzionin e arritur nga specialistët gjeofizikë, që mbi trupat e kromitit mund të merren anomali të fushës manjetike (7), por këto anomali nuk takohen kudo. Ato do të fitohen në ato objekte ku dimensionet e trupit xeheror janë të konsiderueshme në krahasim me thellësinë e shtrirjes së tyre, relievi i përshtatshëm, predspoziteti manjetik i dallueshëm në mes të shkëmbenjve dhe xeherorit.

Vlen të theksohet influenca e madhe negative e relievit në rezultatin e manjetometrisë. Relievi i aksidentuar e deformon dhe e bën jo të qetë fushën manjetike. Mjafton vetëm një përrua i thellë 4-5 m. Për të krijuar anomali, analloge me ato që krijohet mbi trupin e kromitit, kjo gjë vihet re qartë në fig. 6 A. Të gjithë këta faktorë objektivë negativë oulin efektivitetin e metodës manjetometrike për kërkimin e trupave qorre të kromit dhe e bëjnë atë të përdorshëm vetëm në raste të veçanta, të përshtatëshme.

Në vitin 1958-1959 në këto objekte u kryen punime gravimetrike. Rjeti i vrojtimit ishte 20 x 40 m. Kjo lejoi që kryq shtrirjes së trupit të vendoseshin të gjithë objektet mbi 3 pika vrojtimi dhe, gjatë shtrirjes, trupi të intersektohej nga të paktën 3 profile. Vrojtimet u kryen me gradimetrin GAK-3 M dhe variometrin e firmës Etvesh. Përpikshmëria e punimeve ishte e mirë, gabimi mezatar i kuadratuar ishte 0.08 mgl.

Megjithëkëtë, ndërtimi gjeologjik i vendburimeve nuk u pasqyrua në shpërndarjen e forcës së gravitetit. Trupat xëherore pothuajse nuk ndikuan fare në rezultatet e matjes. Kjo gjë duket e qartë në fig. 4.

Këto rezultate negative lidhen me arësyet e mëposhtëme:

a) Trupat xeherore kanë dimensione të vogla në raport me thellësinë e vendosjes së tyre. Pra, akseleracioni i forcës së gravitetit, i kri-

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në

juar nga kjo masë është i vogël. Kjo trajtim se me aparaturën e përdorur dhe saktësinë e arritur, këto anomali nuk mund të fiksohen.

b) Densiteti i shkëmbinjve rrethues (σ = 2,65 gr/cm³) dhe i xeherorëve të përfaqësuar nga kromiti, me pikëzimet mesatare (σ = 2.83 gr/cm³) varion në kufi të gjerë dhe janë të afërt me njëri tjetrin.

Kalkulimet teorike të forcës së gravitetit, vërtetuan këto konkluzione. Në fig. 4 jepet kurba teorike e $\triangle g$ për trupin e kromitit, që i është nënështruar studimit. Vlera maksimale e $\triangle g$ mbi trupin e dhënë është 0.016 mgl.

Polarizimi i provokuar dhe rezultatet e kësaj metode

Gjatë 10 vjetëve të fundit është rritur mjaft interesimi në përdorimin e matjeve elektrike, të njohura nën emërtimin e polarizimit të provokuar. Mendohet se gjatë kalimit të rrymës elektrike nëpër zonën xeherore, lindin në përgjithësi të njëjtat fenomene si dhe gjatë polarizimit të elektrodave.

Metoda e polarizimit të provokuar u përdor në përgjithësi për verifikimin e anomalive të potencialit natyral dhe profilimeve të kombinuara mbi trupat e mineraleve sulfidë, për dallimin e këtyre anomalive nga «anomalitë» e rrema që mund të lindin në zonat e kontakteve tektonike dhe nga lëvizjet e ujrave nëntokësore fig. 7 (1) (18).

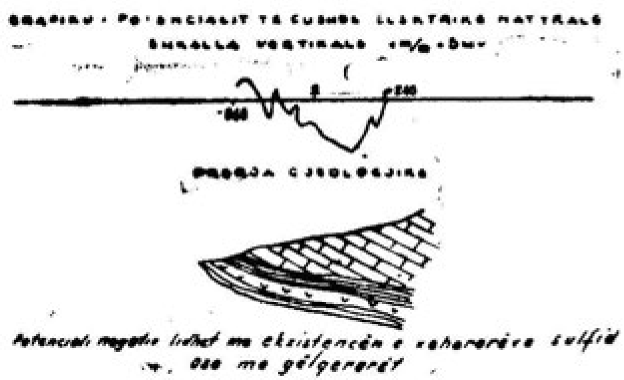

Fig. 7 Grafiku i potencialit të fushës elektrike natyrale për rajonin B. Potenciali negativ mund të lidhet ose me ekzistencën e xeherorizimit sulfid ose me gelqerorët (1).

Përpunimi i metodikës së polarizimit të provokuar është bërë në dy drejtime. Në B.R.S.S. kryesisht është përdorur rryma e vazhduar, kurse në shtetet e perëndimit janë përdorur impulse të rrymës së vazhduar me periode të shkurtër dhe rryma alternative (sinusoidale). Në vendin tonë është përdorur deri tani rryma e vazhduar.

Teoria e metodës së potencialit të provokuar është përpunuar shumë pak. Edhe për variantin më të thjeshtë dhe më të përhapur të metodës së polarizimit të provokuar, në të cilën rryma polarizuese është rryma e vazhduar, mbetet akoma teorikisht e pa studjuar.

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Punimet jo të shumta (3, 5, 11, 12, 13, 14, 19, 20, 21, 23) që janë botuar në kohën e sotme kanë karakter diskutimi ...

nga këto punime tregohet principialisht pamundësija e përdorimit të kësaj metode (20).

Janë bërë përpjekje për kalkulimin teorik të fushave të polarizimit të provokuar të trupave me formë të thjeshtë gjeometrike (5) (11).

Punime eksperimentale me metodën e polarizimit të provokuar tek ne janë bërë në vitin 1960 dhe 1962 në vend-burimet e bakrit, në pjesën veriore të Shqipërisë (18).

Rezultatet e këtyre punimeve me metodat e potencialit natyral, profilimet e kombinuara edhe polarizimin e provokuar, paraqiten në fig. 8.

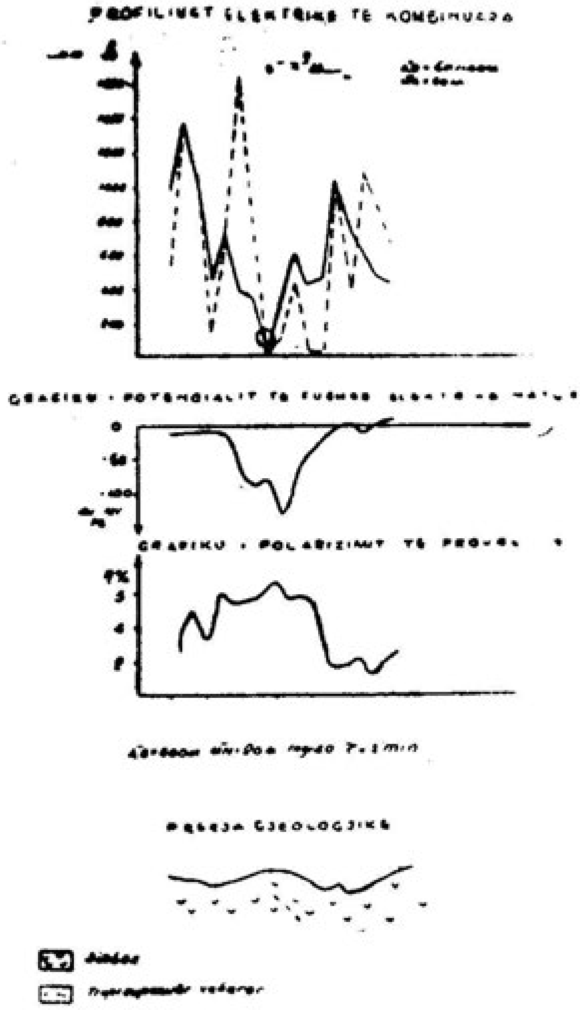

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Fig. 8 Prerje gjeologo-gjeofizike në rajonin «L» e punimeve të vitit 1962, për kërkimin e sulfideve.

Qëllimi ynë në këtë punim nuk është analiza e këtyre fenomeneve, prandaj ne kufizohemi vetëm me përmendjen e tyre.

Zbatimi i metodës së polarizimit të provokuar për gjetjen e mineralizimit sulfid nuk është kaq i thjeshtë, si metod të duket nga sa thamë më lart. Një nga arësyet është se edhe mineralet e tjera gjysmë përçues si grafiti, magnetiti dhe piroluziti japin efektet e ngjajshme të polarizimit të provokuar. Nga ndonjë herë efektin e polarizimit të provokuar mund ta vërejmë edhe atje ku mungojnë mineralet gjysmë përçues.

Është përcaktuar se materialet që polarizohen ruajnë për një farë kohe ngarkesën elektrike dhe mbasi të ndërpritet dërgimi i rrymës elektrike. Në esencë, fenomeni që vrojtohet paraqet në vet vehte gradientin e tensionit, por kjo gjë akoma nuk do të thotë se në të vërtetë kjo është ngarkesë elektrike, në fakt do të ketë vend një farë rjedhje. Efekti i polarizimit të provokuar mund të konsiderohet si grumbullim të energjisë në materialet gjatë kalimit të rrymës dhe që zakonisht një pjesë e saj çlirohet nën veprimin e ngarkesës pas stakimit të rrymës (5). Ekzistojnë pesë lloje të grumbullimit të energjisë: elektrike, manjetike, mekanike, termike dhe kimike. Ka mundësi që në polarizimin e provokuar të marrin pjesë të gjitha llojet e energjisë (5).

Grumbullimi i energjisë elektrike dhe kimike janë format më të thjeshta të efektit të polarizimit të provokuar, që lidhen direkt me mineralet përçuese dhe që janë të ngjajshëm me polarizimin e elektrodave.

Pikërisht ky efekt i polarizimit të provokuar përdoret për kërkimin e mineraleve sulfide të bakrit.

Tjetër formë e grumbullimit të energjisë është grumbullimi i energjisë në fushën manjetike. Është njohur, se rryma elektrike gjithmon formon fushën manjetike, dhe se kur ndërpritet rryma, fusha manjetike, që zhduket, kthen energjinë e grumbulluar në formën e energjisë elektrike. Ky efekt mund të jetë shumë i komplikuar nëqoftëse gjeometria e rrjedhjes së rrymës nuk është e rregulltë, por për format e thjeshta të gjysmë hapësirës ka zgjidhje të mira e të thjeshta (5). Nëqoftëse në punimet fushore përdoren skemat, në të cilat elektrodat vendosen gjatë një vije të drejtë, atëhere efektet elektromanjetike nga pikëpamja cilësore janë të ngjajshëm me efektet e polarizimit në zonat minerale (5).

Format e tjera të grumbullimit të energjisë kanë lidhje me fenomenet elektroosmotike, termoelektrike, të difuzionit dhe të polarizimit të membranës. Këto forma përshkruhen mjaft mirë në punimin e D. J. Marllash dhe Th. R. Madden.

Polarizimi i provokuar në kromite, mendojmë se ka lidhje me grumbullimin e energjisë elektrike dhe kimike, me presencën e magnetitit, që rrethon në formën e cipave kokrizat e kromitit (shif. fig. 8), me ekzistencën e limonitit në disa kromite, në formën e brezave të hollë, ku mundet, të ndodhë grumbullimi i energjisë nën veprimin e presioneve osmotike. Mund të influencojnë edhe format e tjera të grumbullimit të energjisë. .

Punimet elektrometrike u kryhen në dy faza, në laborator dhe në fushë. Punimet laboratorike kishin për qëllim përpunimin e metodikës së vrojtimit dhe verifikimin e rezultateve të arritura me këtë metodë për trupat përçues nga studjonjësit e huaj. 87

Punimet fushore u kryen mbi një trup të kromitit, forma e të cilit është përcaktuar plotësisht nga punimet minerare.

Vrojtimet u kryen duke matur [illegible] skemës së gradientit të mesëm AMNB. Distanca AB = 500 m, MN = 20 metro, hapin 10 m.

Rryma e ngarkesës ishte 4 amperë, kurse koha, që lejohej kjo rrymë të shkonte në tokë ishte 5 minuta.

Këto parametra u zgjodhën në rrugë eksperimentale.

Për këtë, duke mbajtur rrymën e ngarkesës Ing = 2 a koha e ngarkesës u muarr 2, 4, 6, 8, 10, 15 dhe 20 minuta.

Koha optimale e ngarkesës ishte 5 minuta.

Për të caktuar rrymën e ngarkesës, duke mbajtur konstant kohën e ngarkesës T ng = 6' u bë ngarkimi me 1, 2, 3, 4, 5 dhe 6 amperë. Siç duket në figurën 9 potenciali i provokuar në shkëmbenjt ultrabazikë, në mvartësi të rrymës së ngarkesës rritet pothuaj se në formë lineare. Polarizimi i provokuar rri në përgjithësi konstant dhe fillon të rritet pak, vetëm mbas Ing = 5 amperë.

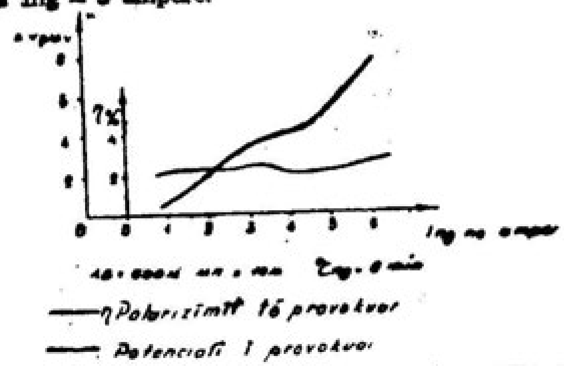

Fig. 9 Mvarësia e potencialit dhe polarizimit të provokuar nga rryma e ngarkesës, për shkëmbinjtë ultrabazikë.

Gjatë këtyre eksperimenteve u vu re një fenomen i tillë: kur rryma e ngarkesës ishte mbi dy amperë, mbas kohës 5-6 minutash rryma në qarkun ushqyes zvogëlohej; mbas 10-12 minutash vlera e saj arrinte 50% të vlerës fillestare të rrymës. Ky fenomen vërehej më tepër në ditët e nxehta, kur toka ishte shumë e thatë. Mbas lagies së vendit të tokëzimit të elektrodave A B, një fenomen i tillë nuk vërehej.

Rënia relativisht e shpejtë e rrymës në qarkun ushqyes lidhet me krijimin e ndonjë cipe me përçueshmëri elektrike të keqe, në tokëzimin, që lidhet me anodën e burimit ushqyes dhe afër tij. Gjatë ndrimit të drejtimit të rrymës, kjo cipë shkatërohej në anodën e vjetër dhe krijohej në anodën e re, por për këte kërkohet përsëri një farë kohe.

Si rezultat i këtyre eksperimenteve, u bë e mundur të theksohen disa faktorë, të cilët përcaktojnë vlerën e polarizimit të provokuar në shkëmbinjtë ultrabazikë:

1) Mvarësia e polarizmit të provokuar nga koha e ngarkesës është e theksuar dhe ka formë të komplikuar. Koha që do të jepte një polarizim të provokuar të madh është mbas 10 minutash ngarkese. Por në këtë rast, do të ndodhë polarizimi i theksuar i elektrodave të qarkut ushqyes, për të cilën u bë fjalë më sipër dhe e elektrodave të qarkut

88 matës. Pra, koha më e përshtatëshme e ngarkesës është 4-8 minuta.

Në figurën 4 dhe 10 jepet kurba e koeficientit të polarizimit të provokuar mbi trupin e njohur të kromitit. Larg trupit xeheror, polarizimi i provokuar merr vlerën $\eta = 3.2\%$. Në zonën afër trupit xeheror dhe mbi të rritet vlera e polarizimit deri në 5-6%. Mbi pjesën e sipërme të trupit $\eta = 10.8\%$. Mendojmë që kjo rritje e theksuar e polarizimit të lidhet me influencën e pjesës së sipërme të trupit, e cila është më afër sipërfaqes.

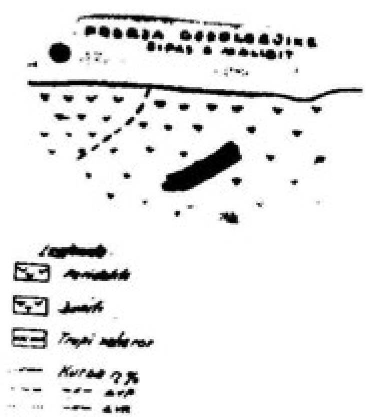

Fig. 10 Grafikët e potencialit të polarizimit të provokuar dhe potencialit natyror në vendburimin e kromit «N». —

Kështu mbi trupin xeheror fitohet një anomali e polarizimit të provokuar me amplitude mesatarisht 2-2.5% më tepër se sfoni e përgjithshëm.

Pra punimet e vitit 1962 dhanë me këtë metodë rezultate pozitive. Megjithëkëtë, vlen të theksohet se këto punime janë kryer në një objekt. Në të ardhëshmen duhet të intersifikohen këto punime. Vetëm në këtë mënyrë do të përpunohet metodika fushore dhe e interpretimit, e cila edhe jashtë shtetit është në fazë eksperimentale dhe do të arrihen konkluzione të plota mbi efektivitetin e kësaj metode për kërkimin e kromiteve.

KONKLUZIONE

Punimet gjeofizike të vendosura në kromitet deri në kohën e sotme, kanë dhënë rezultate të ndryshme për objektet e studjuara. Ka patur rezultate negative dhe pozitive. Duke u mbështetur në analizën e dhënë më lart, kemi arritur në këto konkluzione: 90

1) Jo në të gjithë objektet do të fiksohet anomali e fushës manjetike dhe gravimetrike. Të tilla anomali do të merren në ato vend-burime ku trupat xeherore kanë dimensione të konsiderueshme në lidhje me thellësinë e vendosjes së tyre, shkembënjtë dhe xeherorët të kenë veti fizike (predspozitet manjetik dhe densitet) të dallueshëm nga njeri tjetri.

2) Mbi trupin qorr të kromitit u muarr anomalia e polarizimit të provokuar. Kjo gjë, hap perspektivën e përdorimit të kësaj metode të re për kërkimin e trupave qorre të kromit.

3) Relievi i aksidentuar ul efektivitetin e punimeve gjeofizike. Ai shkakton deformimin dhe bërjen jo të qetë të fushave manjetike, gravimetrike dhe elektrike.

Në përfundim të këtij punimi, duke u bazuar në rezultatet e arritura deri më sot mbi përdorimin e metodave gjeofizike për kërkimin e trupave qorre të kromiteve, për të ardhmen rekomandojmë:

1) Të vazhdojnë punimet eksperimentale me metodën e polarizimit të provokuar. Për këtë duhen kryer eksperimentet në disa objekte në kushte të ndryshme të vendosjes së trupit xeheror, forma, dimensione dhe përbërje mineralogjike të ndryshme, etj. Duhen vazhduar punimet laboratorike. Për të kryer punimet fushore dhe laboratorike është e domosdoshme që aparatura ekzistuese të modifikohet dhe të aplikohet për këtë metodë, pa i ndryshuar parametrat për përdorimin e saj në metodat e tjera.

2) Punimet manjetometrike në koordinim me punimet gravimetrike të vendosen vetëm në disa objekte të përshtatshëm. Për këtë kërkohet, që relievi të jetë i sheshtë, i kategorisë së II-të dhe të III-të, mikrorelievi të jetë i qetë, trupat xeherorë të kenë dimensione të konsiderueshme në raport me thellësinë e vendosjes së tyre.

3) Për të kryer vrojtimet fushore me këtë metodë është e domosdoshme që matjet të kryhen me aparate preçizioni, manjetometëra, që kanë vlerën e një ndarjeje rreth 10 gama dhe gravimetra që kanë saktësinë 0,05–0,01 mgl.

4) Të fillojmë studimet laboratorike petromanjetike për të njohur sa më mirë vetitë fizike të shkëmbenjve, e cila është konditë kryesore dhe e domosdoshme në interpretimin e të dhënave fushore.

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9. «Instruksion mbi zhvillimin e punimeve manjetometrike në RPSH»
10. JAKUBOVSKIJ LJAHOV «Elektrorazvjedka» Moskva 1956
KOMAROV V. A. «Elementi teorii metoda vizvanoj polarizacii» Trudi VIT Sbornik 3 Moskva 1961.

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2) Mbi trupin qorr të kromitit u muarr anomalia e polarizimit të provokuar. Kjo gjë hap perspektivën e përdorimit të kësaj metode të re për kërkimin e trupave qorre të kromit.

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Në përfundim të këtij punimi, duke u bazuar në rezultatet e arritura deri më sot mbi përdorimin e metodave gjeofizike për kërkimin e trupave qorre të kromiteve, për të ardhmen rekomandojmë:

1) Të vazhdojnë punimet eksperimentale me metodën e polarizimit të provokuar. Për këtë duhen kryer eksperimentet në disa objekte në kushte të ndryshme të vendosjes së trupit xeheror, forma, dimensione dhe përbërje mineralogjike të ndryshme, etj. Duhen vazhduar punimet laboratorike. Për të kryer punimet fushore dhe laboratorike është e domosdoshme që aparatura ekzistuese të modifikohet dhe të aplikohet për këtë metodë, pa i ndryshuar parametrat për përdorimin e saj në metodat [illegible]

2) Punimet [illegible] në koordinim me punimet gravimetrike [illegible] vetëm në disa objekte të përshtatshëm. Për këtë kërkohet, që relievi të jetë i sheshtë, i kategorisë së II-të dhe të III-të, mikrorelievi të jetë i qetë, trupat xeherorë të kenë dimensione të konsiderueshme në raport me thellësinë e vendosjes së tyre.

3) Për të kryer vrojtimet fushore me këtë metodë është e domosdoshme që matjet të kryhen me aparate preçizioni, manjetometëra, që kanë vlerën e një ndarjeje rreth 10 gama dhe gravimetra që kanë saktësinë 0,05-0,01 mgl.

4) Të fillojmë studimet laboratorike petromanjetike për të njohur sa më mirë vetitë fizike të shkëmbenjve, e cila është kondită kryesore dhe e domosdoshme në interpretimin e të dhënave fushore.

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DY MËNYRA PËR PËRPUNIMIN E REZULTATEVE TË VROJTIMEVE GJEOFIZIKE ME NDIHMËN E MAKINAVE LLOGARITËSE ELEKTRONIKE*

Frashëri A., Beqiraj G., Vejsiu Y.,

Përmbledhje Studimesh, Nr. 4. 1973

Shfrytëzimi i makinave llogaritëse elektronike krijon edhe për gjeofizikën mundësi të mëdha për të shpejtuar dhe për të saktësuar përpunimin e të dhënave të vrojtimeve fushore dhe laboratorike si edhe për të thelluar e zgjeruar interpretimin gjeologo-gjeofizik të këtyre të dhënave, çka ndihmon në rritjen e efektivitetit të kërkimeve gjeofizike.

Drejtimet kryesore, në të cilat mund të kryhen sot tek ne përpunimi dhe interpretimi i të dhënave të gjeofizikës xeherore me makina llogaritëse elektronike janë:

1. Llogaritja e koeficientëve të skemave të profileve elektrike të gradientit të mesëm dhe e koeficientëve të tjerë, që shfrytëzohen në barazimet e përhapjes së fushës elektromagnetike.

2. Studimi statistikor i plotë i rezultateve të përcaktimeve petrografike të xeherorit dhe të shkëmbinjve rrethues, për të përcaktuar ligjësitë e ndryshimit të tyre: lidhja ndërmjet vetive fizike dhe përbërjes mineralogjiko-kimike të xeherorit ose të shkëmbinjve: këto të dhëna bëjnë të mundur që të vlerësohen kufijtë e ndryshëm fizikë dhe të gjykohet mbi anomalitë e pritshme, duke studiuar edhe natyrën e fenomeneve të vrojtuara;

3. Përpunimi statistikor i vlerave të parametrave fizikë të vrojtuara, kryerja e analizës së trendit dhe veçimi i anomalive, të shoqëruara edhe me vlerësimin për shkallën e besueshmërisë së tyre;

4. Llogaritja analitike e anomalive të fushave fizike mbi trupa me trajta gjeometrike të njohura dhe të thjeshta;

5. Transformimi i fushave etj.

Natyrisht, është akoma herët dhe kërkohet një punë shumë e madhe për të përvetësuar e për të përpunuar metodikat e nevojshme të përshtatshme për makinat llogaritëse elektronike si dhe për hartimin e programeve për këto makina. Megjithëkëtë, për disa nga problemet më të thjeshta, janë hedhur hapat e para dhe janë marrë rezultate të mira. Janë hartuar programe për studimin statistikor të parametrave të matur, për filtrimin e anomalive të frekuencave të ndryshme, për llogaritjen e parametrit kompleks, për llogaritjen e koeficientëve të skemës së profilimit të gradientit të mesëm etj.

1. Filtrimi i anomalive të frekuencave të ndryshme

Fushat fizike shpeshherë janë shumë të turbullta. Kjo gjë është pasojë e mbivendosjes së anomalive të "frekuencës së lartë", që shkaktohen nga heterogjenitetet pranësipërfaqësore ose nga mikrorelievi, mbi anomalitë e "frekuencave të ulta", që shkaktohen nga objektet gjeologjike që kërkohen. Ky turbullim shprehet me dhëmbëzimin e grafikëve të intensitetit të fushave fizike, i cili vështirëson interpretimin e tyre, pra krijon "zhurma" me nivel dhe frekuencë të caktuar.

Që të nxirren në pah anomalitë e shkaktuara nga objektet që kërkohet, duhet të veçohen anomalitë me frekuencë të ulët nga ato me frekuencë të lartë. Ky veçim mund të bëhet me mënyrën e "filtrimit".

Për të kryer filtrimin ekzistojnë shumë mënyra. Ne eksperimentuam mënyrën e "mesatarizimit rrëshqitës". Ky filtrim lejon:

* Botuar në Përmbledhje Studimesh, Nr.4, 1973, f. 83-96.

a) veçimin e anomalive me frekuencë të lartë nga ato me frekuencë të ulët, përcaktimin e amplitudës së secilës anomali dhe ndërtimin e grafikut përkatës të ndryshimit të tyre në të gjithë sheshin e relievuar;

b) shmangien e anomalive të rastit, që fiksohen në një ose në disa piketa të një profili;

c) regjistrimin e anomalive të dobëta.

Mesatarizimi u krye me peshë në pikën e vrojtimit. Ai mund të jetë rrëshqitës linear ose sipërfaqësor, që, përkatësisht llogaritet me këto formula:

$$\overrightarrow{A_i} = \frac{1}{2}\left(A_i + \frac{A_{i-1} + A_{i+1}}{2} \right) \qquad (1)$$

$$\overrightarrow{A_i} = \frac{1}{2}\left(A_i + \frac{A_{i+2} + A_{i+1} + A_{i-1} + A_{i-2}}{4} \right) \qquad (2)$$

ku:

A - vlera e parametrit të matur në piketën i;

A_1 - vlera mesatare e parametrit në piketën *i* të një profili të caktuar.

Skemat e kombinimit të piketave për mesatarizimin linear përkatësisht tregohet në fig.1.

Fig. 1. Skemat e mesatarizimit rrëshqitës linear.

Në rastin e mesatarizimit sipërfaqësor, formula llogaritëse ka trajtën:

$$\overrightarrow{A_{i,j}} = \frac{1}{2}\left(A_{i,j} + \frac{A_{i+1,j} + A_{i-1,j} + A_{i,j-1} + A_{i,j+1}}{4} \right) \qquad (3)$$

Skema përkatëse e zgjedhjes së piketave është treguar në fig. 2.

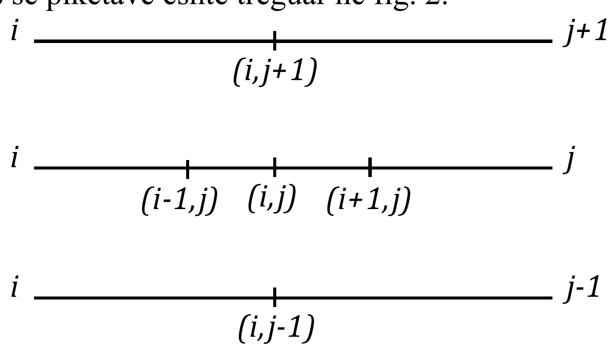

Fig. 2: Skema për mesatarizimin rrëshqitës sipërfaqësor.

Nga barazimet e mësipërme duket se për pikën e dhënë mesatarja rrëshqitëse formohet në rrugën e përgjithësimit të rezultateve të disa pikave para dhe pasardhëse.

Me qëllim ilustrimi, më poshtë po ekspozojmë vetëm programin e mesatarizimit rrëshqitës sipërfaqësor, sepse ai është më tipik:

```
BEGIN    REAL  N1, N2, M1, M2: INPUT O: N1, N2, M1, M2;
BEGIN    ARRAY        A [N1, N2, M1, M2], AM [N1+1, N2-1, M1+1, M2-1];
INPUT    1:A;
FOR      I: = N1 + 1 STEP 1 UNTIL   N2 - 1  DO
```

```
FOR       J: M1+1 STEP 1 UNTIL M2 - 1 DO
AM [I,J]: = 1/2 X A [I, J] + A [I + 1,J] + A [I-I,J] + A [I,J - I] + A [I,J + I] (4);

PRINT 3: AM
END
END
```

Në këtë program, instruksionet BEGIN dhe END përdoren për të sinjalizuar fillimin dhe mbarimin e një bloku llogaritës.

Instruksionet REAL N_1, N_2, M_1, M_2; INPUT O: N_1, N_2, M_1, M_2; i japin makinës, përkatësisht, numrin fillestar dhe numrin përfundimtar të piketave (N1, N2) të çdo profili si dhe numrin fillestar dhe numrin përfundimtar të profileve (M1, M2).

Instruksionet ARRAY A [N_1: N_2, M_1: M_2], AM [N1+1: N2-1, M1+1: M2-1]; INPUT 1:A, shërbejnë për futjen në makinë të vlerave të matura të parametrit për të gjitha profilet si edhe për përgatitjen e makinës për të llogaritur vlerat e mesatares rrëshqitëse.

FOR I: = N1 +1 STEP 1 UNTIL N2-1 DO
FOR J: = M1+1 STEP 1 UNTIL M2-1 DO
AM[I,J]: = 1/2 x (A[I,J] + (A[I-1,J] + A[I,J-1] + A[I,J+1])/4, është instruksioni qendror i programit. Aty janë pasgyruar me besnikëri si skema llogaritëse, ashtu edhe kufitë dhe rregulli i ndryshimit të numrave të piketave dhe të profileve.

Më në fund shtojmë se instruksioni PRINT 3:AM shërben për të nxjerrë në shtyp rezultatet e llogaritura nga maqina. Rezultatet dalin në trajtën e një pasqyre të ndarë në grupe sipas profileve.

Programi është shkruar në gjuhën ALGOL, me të cilën punon makina elektronike kineze e tipit DJS-7. Ai presupozon që në të gjitha profilet numri i piketave të jetë i njëjtë. Në qoftë se të dhënat fushore nuk fillojnë e as mbarojnë në piketa me numër të njëjtë, atëherë, si numër fillimi (N1) merret minimumi i numrave fillestarë për të gjitha profilet dhe si numër mbarimi merret maksimumi i numrave përfundimtare për të gjitha profilet. Për ato profile që janë më të shkurtëra se sa profili me fillim në N1 dhe me mbarim në N2, piketat në të cilat nuk janë bërë matje, mbushen me zero; pas llogaritjes këto piketa nuk merren parasysh.

Vlerat e matura të parametrit radhiten sipas profileve, duke nisur nga ai me numër rendor më të vogël.

Përpara se të futen në makinë, vlerat duhet të kalojnë nëpër dy procese: 1) në kodim dhe 2) në perforim.

Mënyra e kodimit është mjaft e thjeshtë, sa që mund të kryhet fare lehtë edhe nga një teknik që punon jashtë Qendrës llogaritëse.

Për të sqaruar metodën e kodimit po tregojmë disa shembuj.

1) numri +32,49 kodohet 032492;
2) numri -4,329 kodohet 143291;
3) numri +34,8 kodohet 034802,

Siç shihet nga shembujt e paraqitur më sipër, shifra e parë paraqet shenjën e numrit 0 për + dhe 1 për shenjën -. Shifra e fundit paraqet numrin e shifrave që ndodhen para presjes dhjetore, kurse zona ndërmjetëse e kodit formohet nga shifrat e numrit. Në këtë mënyrë, të dhënat e koduara perforohen në një shirit letre të posaçme. Ky i fundit futet në makinë pas hyrjes së programit.

Lloji i mesatarizimit linear apo sipërfaqësor zgjidhet në varësi të privijëzimit të anomalive dhe të përmasave të tyre. Kështu, për shembull, për të "sheshuar" lakoret e rezistencës së dukshme të matur me anën e profilimeve elektrike të kombinuara është përdorur mesatarizimi linear pesëintervalesh (fig. 3).

Nga fig. 3 vihet re se mesatarja rrëshqitëse fsheh maksimumet dhe minimumet; lakoret e rezistencës së dukshme bëhen më të rregullta dhe "kryq, i drejtë" dallohet më qartë.

Të dhënat e relievimit sipërfaqësor magnetometrik, kur kanë ekzistuar anomali lineare, janë mesatarizuar në plan (fig. 4).

Në lakoret e mesatarizuara, që tregohen në fig. 4-b, dalin më në pah anomalitë e vogla që shtrihen nëpër Pk 20 dhe 50, lakoret bëhen më pak të dhëmbëzuara dhe minimizohet ndikimi i heterogjeniteteve të padobishme.

Anomalitë e "frekuencës së lartë" nuk janë gjithnjë "zhurma" që duhen "shuar". Nganjëherë, ato pasqyrojnë ndërtimin shumëheterogjen të shkëmbinjve dhe mund të shërbejnë si shenjë dallimi i llojeve të ndryshme të shkëmbinjve. Prandaj, në këto raste, pas mesatarizimit rrëshqitës, për të gjitha pikat e vrojtimit llogaritet madhësia e anomalisë me "frekuencë të lartë".

$$\Delta A_{i,j} = \overline{A}_{i,j} - A_{i,j}$$

Pastaj ndërtohet lakorja përkatëse për profilin. Për këto të dhëna, llogaritet edhe shmangja mesatare kuadratike:

$$\sigma = \sqrt{\frac{\sum_{i-1}^{n} (A_{i,j} - \Delta A_{i,j})^2}{n}} \qquad (5)$$

e cila lejon që të vlerësohet në mënyrë sasiore ndryshueshmëria e parametrit fizik me frekuencë të lartë të matur mbi lloje të ndryshme shkëmbinjsh.

Mënyra e filtrimit të anomalive, me programin e mësipërm, u përdor edhe në dy sheshe të mëdha, për të përpunuar rezultatet e vrojtimeve magnetometrike dhe dha rezultate pozitive.

2) LLOGARITJA E PARAMETRIT KOMPLENS TË FUNKSIONIT PËRGJITHËSUES.

Në vendin tonë, për kërkimin e xeherorëve përdoret një kompleks i gjerë metodash gjeofizike dhe gjeokimike.

Ekzistojnë disa mënyra për të paraqitur rezultatet e studimeve të shumë metodave në trajtën e një funksioni përgjithësues të vetëm, duke llogaritur një **parametër kompleks (T).** Në këtë parametër kompleks përgjithësohen parametrat e disa fushave fizike ose kimike të vrojtuara. Prandaj, para së gjithash, shmangen dallimet në përmasat e parametrave të matura të secilës fushë në veçanti. Për këtë, në literaturën përkatëse rekomandohet (5) përdorimi i **treguesit të kontrastit**, sidomos për anomalitë e dobëta, i cili llogaritet me formulën:

$$G_{i,j} = \frac{A_{i,j} - A_{si}}{S(A_i)} \qquad (6)$$

ku: A_{ij} - vlera e parametrit *i* të matur në pikën *j* të vrojtimit;

A_{si} dhe $S(A_i)$ - përkatësisht vlera e sfondit dhe shmangia mesatare kuadratike e parametrit në zonën e fushës normale.

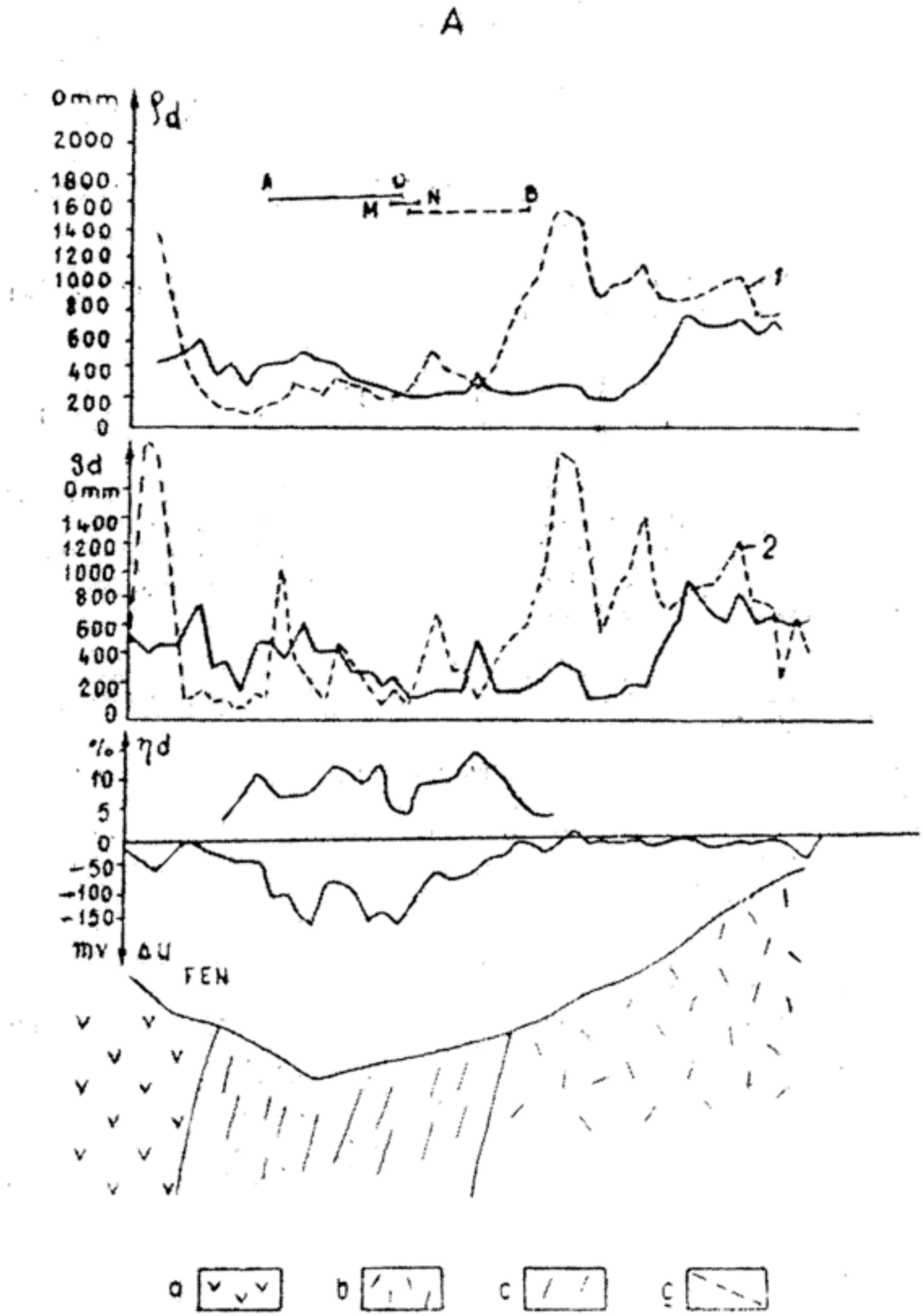

Fig. 3/a

Fig. 3: Lakoret e rezistencës së dukshme sipas profileve elektrike të kombinuara.

A - Mbi një zonë me mineralizim sulfuresh me pikëzime në rajonin e Pukës.

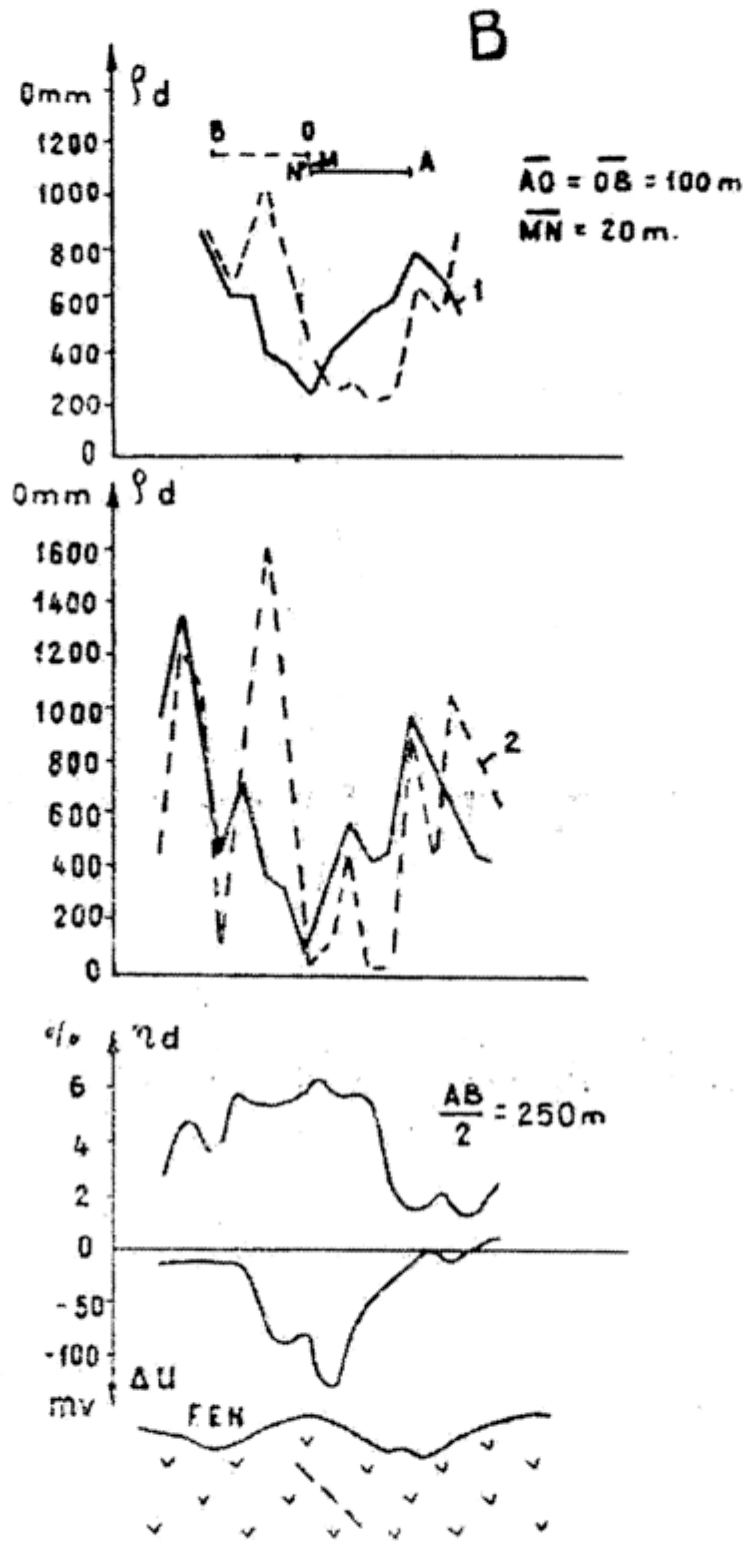

Fig. 3.b

B - Mbi një zonë të mineralizuar me sulfure në rajonin e Kukësit.

1- Pas mesatarizimit; 2. para mesatarizimit.

a. diabaze, b. spilite, c. zona e mineralizuar, ç. eksituesi.

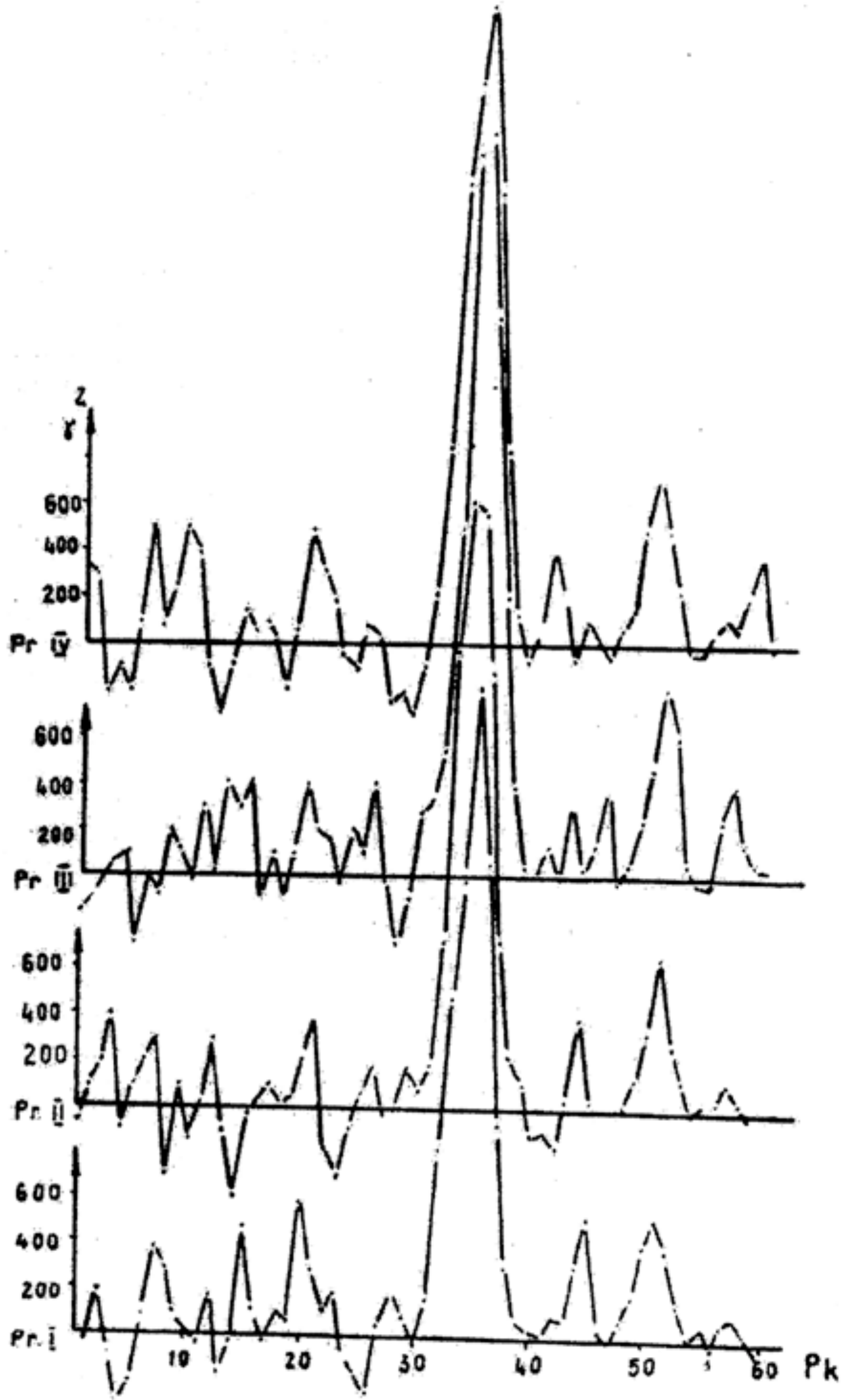
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Fig. 4/a

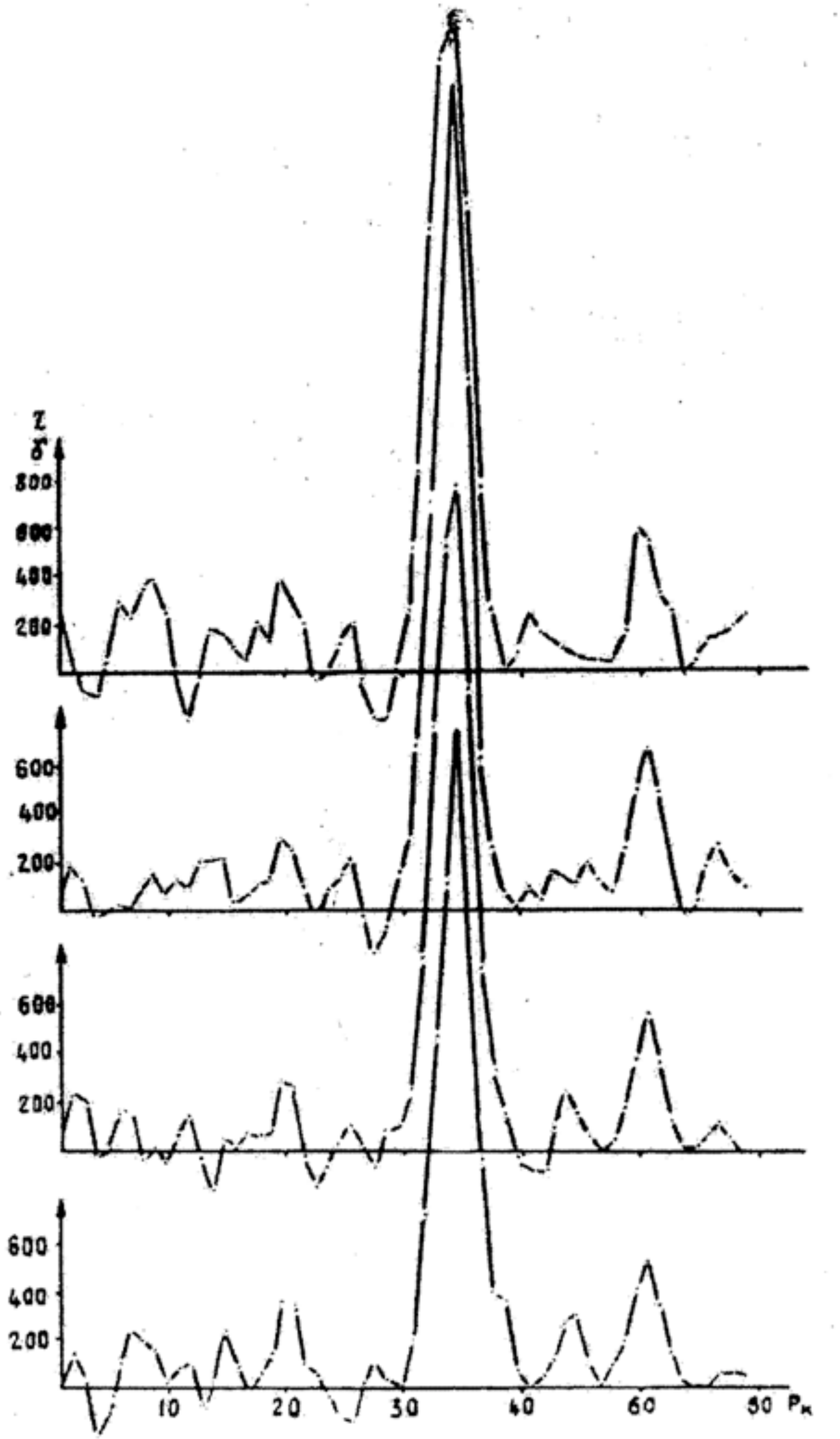

Fig. 4/b

Fig. 4: Lakoret e komponentit vertikal të fushës magnetike para mesatarizimit (a) dhe pas mesatarizimit sipërfaqësor (b)

Ky tregues lejon të merret parasysh intensiteti i shfaqjes së sinjalit të dobishëm në sfondin e zhurmave, duke e paraqitur këtë intensitet në madhësi pa përmasa.

Nga llogaritjet teorike të bëra dhe nga eksperimentimet e kryera është arritur në përfundimin se ky tregues duhet përdorur vetëm për $S(A_i)>1$. Dhe kjo, jo sepse formula nuk është e vërtetë, por, sepse nuk është i drejtë zbatimi i saj në intervalin $0<S(A_i)>1$. Nga formula 6, duket se kur $S(A_i)<1$, treguesi i kontrastit zmadhohet sa më shumë që i afrohet zeros $S(A_i)$; domethënë, sa më homogjene bëhet fusha fizike. Ky përforcim i amplitudave të anomalive "pa përmasa" i vendos ato në kushte të pabarabarta për metodat e ndryshme të përdorura, mbasi dihet se rëndësia e anomalisë varet jo nga shmangia mesatare kudratike e parametrave të matura në zonën e fushës normale, por kushtëzohet, veç të tjerave, nga amplituda e saj mbi prag. Për të shmangur këtë të metë rekomandojmë që kur $0< S(A_i)>1$, në vend të treguesit të konstratit, të përdoret parametri i shprehur në milimetra:

$$K_{i,j} = \frac{\mathrm{A_{ij}} - \mathrm{A_{si}}}{\mathrm{Sh_A}} \qquad (7)$$

ku: Sh_A - shkalla e paraqitjes grafike të parametrit A_i.

Për parametrat e kompleksit që kanë $S(A_i)>1$, rekomandojmë të përdoret treguesi i kontaktit, që shprehet në milimetra:

$$K_{i,j} = \frac{\mathrm{A_{i,j}} - \mathrm{A_{si}}}{\mathrm{Sh_A} S(A_i)} \qquad (8)$$

Në këtë mënyrë, njëkohësisht, merret parasysh intensiteti i shfaqjes së sinjalit të dobishëm në sfondin e zhurmave dhe anomalitë mbipërforcohen "artificialisht".

Funksioni i përgjithësuar i treguesit kompleks zgjidhet duke pasur parasysh që të sigurojë veçimin me qartësi të mjaftueshëm të sinjalit të dobishëm dhe, njëkohësisht, mbytjen maksimale të zhurmave, duke përdorur formula të thjeshta. Pra, ai duhet të nxjerrë në pah anomalitë e fiksuara me të gjitha metodat mbi të njëjtin trup. Sidomos, duhet të përforcojë anomalitë e dobëta dhe të zvogëlojë veprimin e anomalive (zhurmave) që kushtëzohen nga objekti joperspektivë.

Për llogaritjen e parametrit kompleks T, njihen disa formula, të cilat marrin parasysh edhe llojet e ndryshme të trajtave të shfaqjes së sinjaleve të dobishme, që fiksohen me metoda të ndryshme mbi objektet xeherore.

Ne kryem eksperimentin për rastin kur sinjalet e dobishme kanë trajtë afërsisht të njëjtë, por shenjë të ndryshme. Si model na shërbeu një trup prizmatik kalkopiriti, me dy përmasa, i vendosur ndërmjet diabazeve. Trupi ka trashësi 2b=5 m, zgjatet sipas rënies 50 m, ka kënd rënieje vertikale dhe në rastin e parë, skaji i sipërm ndodhet 5 m thellë, kurse në një rast të dytë, 25 m thellë. Trupi ka dendësi mbetëse 0.74 g/cm^3, polarizueshmëri mbetëse 38% dhe magnetizëm mbetës 1900 x 10^{-6} CGSM. Ai i është nënshtruar procesit të oksido-reduktimit (fig. 5).

Siç duket nga fig. 5, mbi trup fiksohen anomali të ΔU_{FEN} , η_{an}, Z, W_{zz}, që janë shumë të dobëta kur trupi është vendosur në 25 m. thellë. Afër trupit zeheror është supozuar edhe një tektonikë shkëputëse, e cila shkakton anomali intensive të FEN. Për të llogaritur parametrin kompleks përdorim formulën 5:

$$T = |A| \overset{x}{+} |B| \overset{x}{+} |C| \overset{x}{+} |D| \qquad (9)$$

Nga lakorja e përllogaritur e parametrit T, vihet re se përforcohet anomalia e dobët që shkaktohet nga trupi që gjendej 25 m thellë dhe shmanget anomalia e FEN mbi tektonikën shkëputëse, e cila nuk është fiksuar me metoda të tjera.

Kur nuk kërkohet të "shtypen" anomali "joxeherore", për të llogaritur parametrin T mund të përdoret edhe formula më e thjeshtë [5]:

$$T = |A| + |B| + |C| + ... + |D|. \qquad (10)$$

Bazë për programimin është formula 6. Por emëruesi i kësaj thyese ka nevojë për t'u zhvilluar më tej.

Le të jenë $B_1^i, B_2^i, ...B_m^i$, vlerat e sfondit në zonën e fushës normale.

Atëherë, shmangia kuadratike mesatare e parametrit jepet nga formula:

$$S(A_i) = \sqrt{\frac{\sum_{K=1}^{m} (B_k^i - A)^2}{m-1}} \qquad (11)$$

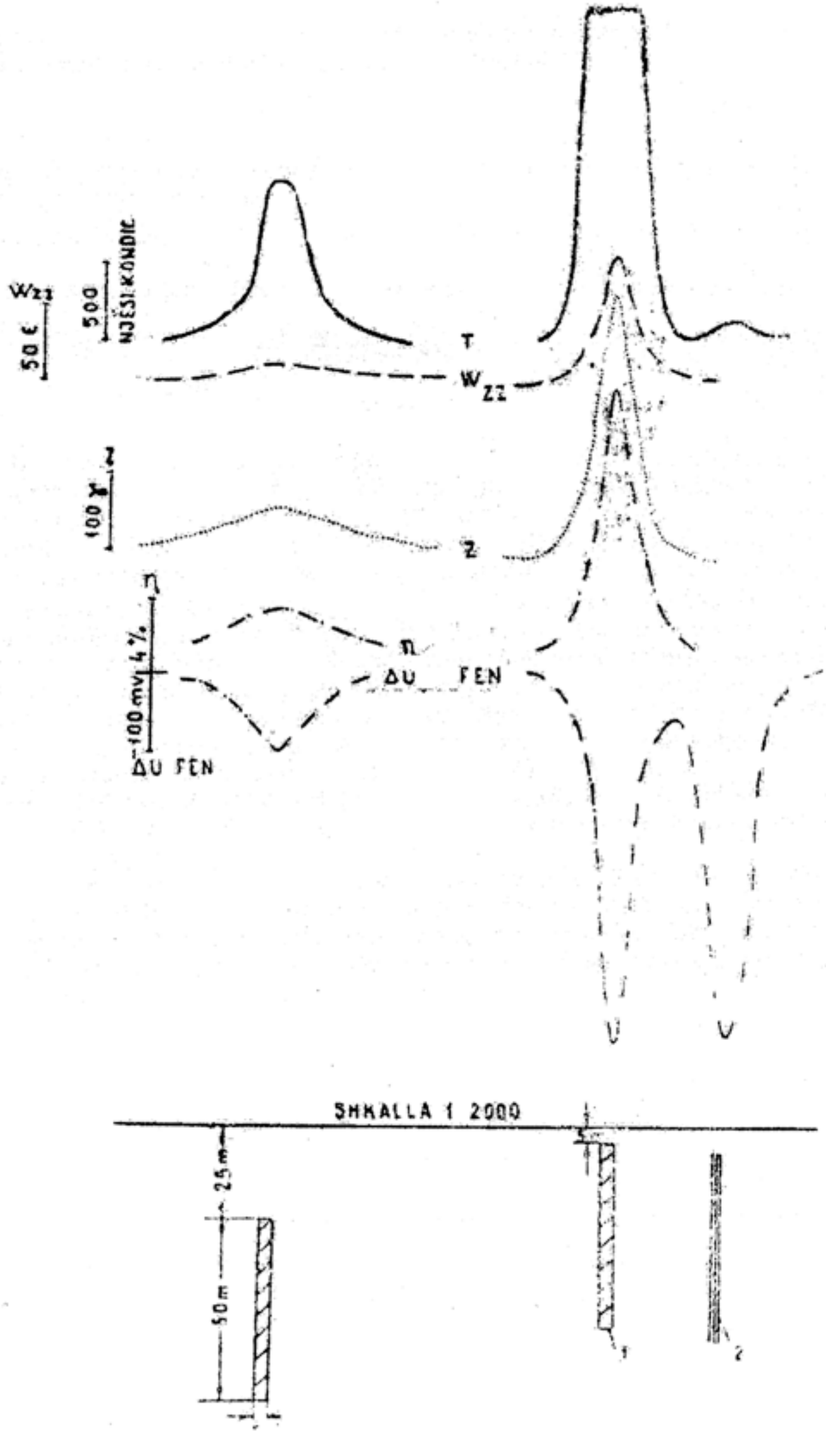

Fig. 5: Anomalia e parametrit kompleks (T) mbi një trup kalkopiriti, që është vendosur në thellësi të ndryshme.

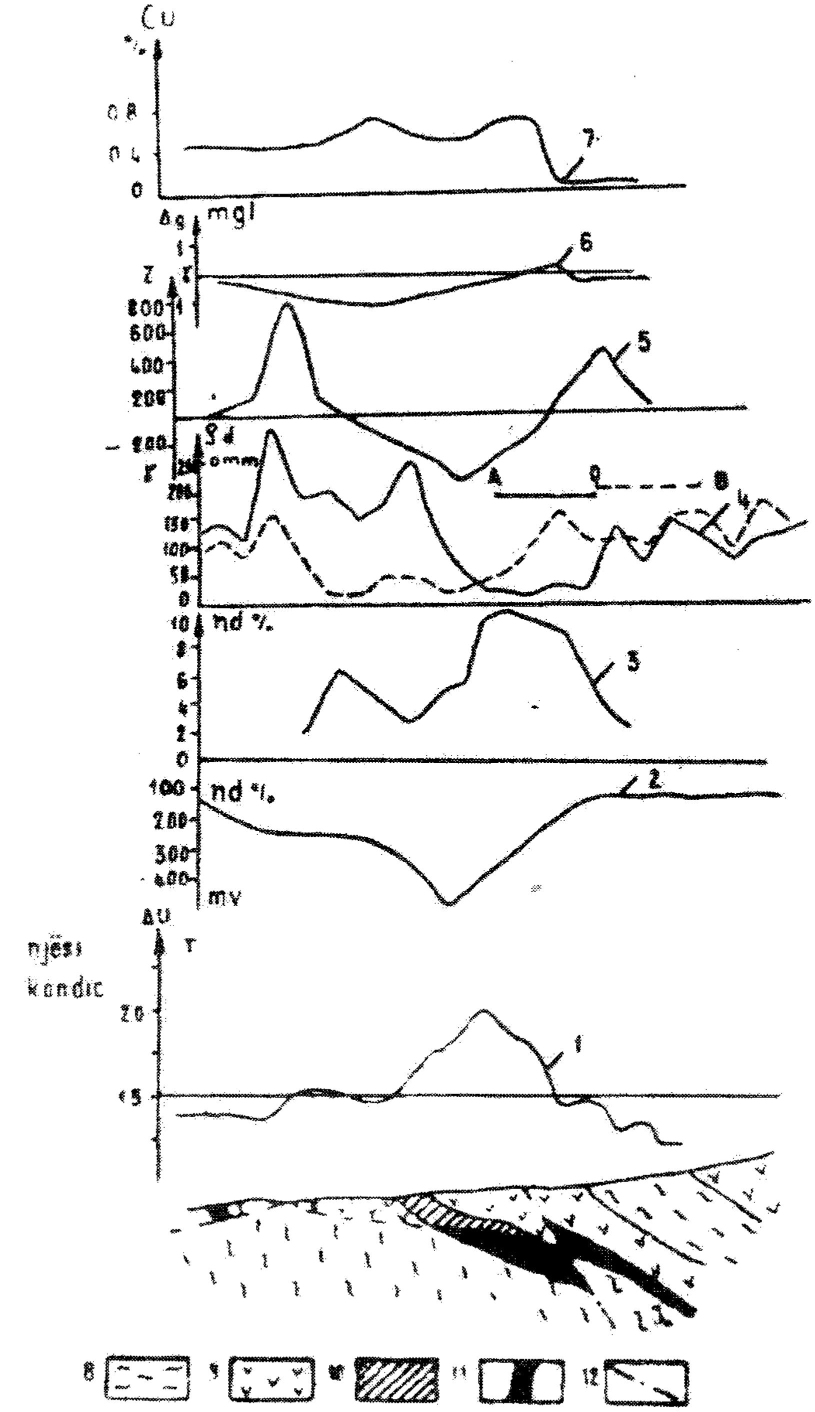

Fig. 6: Prerje gjeologo-gjeofizike e një vendburimi me zeherorë masivë sulfidë bakri, që lidhen me formacion efuzivo-sedimentar.

1 - lakorja e parametrit kompleks T; 2 - lakorja e potencialit të fushës elektrike natyrore; 3 - lakorja e koeficientit të polarizimit të provokuar; 4 - lakorja e rezistencës së dukshme sipas profilimeve elektrike të kombinuara; 5 - lakorja e komponentit vertikal të intensitetit të fushës magnetike; 6 - lakorja e forcës së gravitetit; 7- lakorja e përmbajtjes së bakrit në aureolën dytësore; 8 - rreshpe argjiloro-strallore; 9 - diabaze; 10 - kapele hekuri; 11 - trup xeheror me teksturë masive; 12 - tektonikë shkëputëse.

Të dyja këto formula (6, 11), programohen sipas parimeve të njëjta, që u paraqitën më sipër. Në program parashikohet, gjithashtu, edhe llogaritja e parametrit kompleks sipas formulave 9 ose 10. Të dhënat fillestare

futen në makinë pjesë-pjesë, sipas natyrës fizike të parametrit. Çdo grup të dhënash përmbledh vlerat e parametrit A_i, si edhe ato të sfondit të fushës normale B_k^i.

Me programin e hartuar u llogarit parametri kompleks T edhe sipas një profili që ndodhet mbi një vendburim sulfid bakri të njohur në rajonin e Kukësit (fig. 6). Për kërkimin e këtij vendburimi janë përdorur metodat gravimetrike, magnetometrike, të rezistencës së dukshme, e polarizimit të provokuar, fusha elektrike natyrore dhe gjeokimike. Nga lakorja e T e fig. 6 duket që me parametrin kompleks gjen pasqyrim të qartë vetëm trupi xeheror dhe "ngjishen anomalitë" joxeherore, për shembull të PK, 2 deri në 4.

Përveç këtij profili, parametri kompleks u llogarit edhe në një shesh të madh ku janë kryer studime komplekse për kërkimin e kromit dhe u muarrën rezultate pozitive.

Është vënë re se, kur krahas metodave-gjeofizike, përdoren dhe studime gjeokimike, rezultate të mira merren në qoftë se është studiuar aureola parësore dhe mund të shfrytëzohet edhe aureola dytësore, po qe se ëshë e sheshtë; në rast të kundërt, ajo do të jetë e zhvendosur nga anomalitë gjeofizike dhe anomalia e parametrit T deformohet.

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NR. 2 BULETINI I SHKENCAVE TË NATYRËS 1979

NJË ALGORITËM PËR LLOGARITJEN E KURBAVE TEORIKE TË SONDIMEVE VERTIKALE ELEKTRIKE

A. FRASHËRI, G. BEQIRAJ, N. FRASHËRI

Sondimi vertikal elektrik është metodë e rëndësishme e elektrometrisë që përdoret në vendin tonë për kërkimin e strukturave perspektive naftë-gazmbajtëse të xeherorëve dhe të mineraleve të tjera të dobishme, si edhe për zgjidhjen e detyrave të gjeologjisë inxhinerike. Në të ardhmen do të zgjerohet përdorimi i saj.

Metodika racionale e vrojtimit të sondimit, d.m.th. zgjedhja e tipit të skemës dhe përmasat optimale të saj, si edhe interpretimi sasior i rezultateve të sondimit, në përputhje me ndërtimin gjeoelektrik konkret të rajonit që studiohet, kërkojnë një sasi të madhe kurbash teorike për modele të njohura të pritshme të prerjeve gjeoelektrike.

Albumet që disponojmë të kurbave teorike të sondimeve për prerjet shumë shtresore nuk përmbajnë sasinë e nevojshme të kurbave që t'u përgjigjen të gjitha rasteve që takohen në vendin tonë dhe që kërkohet të interpretohen. Metodat grafike të njohura nuk sigurojnë saktësinë e kërkuar. Nga ana tjetër, nuk disponojmë albume kurbash teorike të sondimeve me lloje të ndryshme skemash të zbatuara në kushte të ndryshme. Prandaj e pamë të domosdoshme dhe plotësisht të mundshme llogaritjen dhe ndërtimin e kurbave teorike të sondimeve vertikale elektrike me anën e makinave llogaritëse elektronike. Zgjidhja e këtij problemi shërben për zgjidhjen e detyrës së zhdrejtë të elektrometrisë me anën e makinave llogaritëse elektronike, d.m.th. të parametrave të prerjes gjeoelektrike sipas kurbave të vrojtuara.

Për të realizuar këtë detyrë deri tani janë hartuar programet standarde në gjuhën Algol, për prerjet dy, tre dhe më shumë shtresore për sondimet vertikale elektrike me skemë simetrike AMNB dhe dipolare boshtore ABMN në stere dhe me skemë fundore në det. Këto programe janë kolauduar deri tani në modele të njohura për prerjet trishtresore dhe po vazhdon puna për llogaritjen e prerjeve me më shumë shtresa.

Algoritmi u ndërtua për prerjet gjeoelektrike shumështresore, me kufij ndarës horizontalë (fig. 1). Siç duket në fig. 1 me ρ_1, ρ_2,... ρ_n janë shënuar rezistencat elektrike të shtresave horizontale nga lart poshtë. Trashësitë e shtresave janë shënuar me gërmat h_1, h_2,... h_n, ndërsa thellësitë e shtrirjes së kufijve të tyre me gërmat H_2, H_3,... H_n, duke filluar nga sipërfaqja. Rezistencat elektrike specifike u llogaritën

me rrugën e mirënjohur të përcaktimit të potencialit të fushës elektrike me anën e integrimit të ekuacionit të Laplasit [1].

$$\frac{\partial^2 u}{\partial r^2} + \frac{1}{r}\frac{\partial u}{\partial r} + \frac{\partial^2 u}{\partial z^2} = 0 \qquad (1)$$

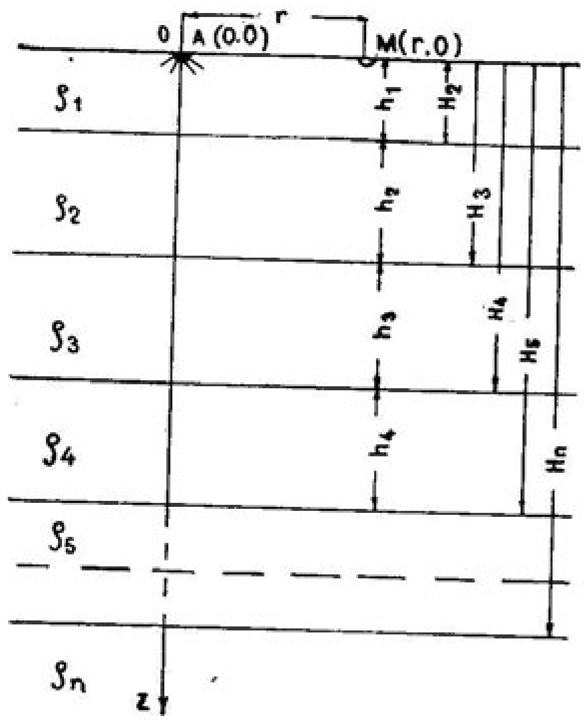


Fig. 1

Për rastin e skemave sipërfaqësore, programi u hartua mbi bazën e zgjidhjes së njohur [1] të ekuacionit (1), që, për prerjet shumë shtresore, është:

$$\rho_d = \rho_1 \left[1 + 2 \sum_{n=1}^{\infty} q_n f_s\right] \qquad (2)$$

ku ρ_1 — rezistenca elektrike specifike e shtresës së parë:
q_n — funksioni i emisionit që varet nga parametrat e prerjes gjeoelektrike $q_n = f(\rho_1, \rho_2, \ldots, \rho_n, h_1, h_2, \ldots, h_n)$;
f_s — funksioni që varet nga lloji dhe përmasat e skemës.
Funksioni f. për skemën simetrike AMNB është:

$$f_s = \frac{\left(\frac{r}{h_1}\right)^3}{\left[\left(\frac{r}{h_1}\right)^2 + 4n^2\right]^{3/2}} \qquad (3)$$

për skemën dipolare boshtore ABMN është:

$$f_s = \frac{\left(\frac{r}{h_1}\right)^3\left[\left(\frac{r}{h_1}\right)^2 - 2n^2\right]}{\left[\left(\frac{r}{h_1}\right)^2 + 4n^2\right]^{5/2}} \qquad (4)$$

ku: r — gjysma e gjatësisë së skemës simetrike $\frac{AB}{2}$ ose largësia midis qendrave të dipoleve O_1 O_2;

h_1 — trashësia e shtresës së parë, e barabartë edhe me masën e përbashkët të trashësive (h_0) të shtresave.

Funksioni i emisionit q_n u llogarit duke u nisur nga funksioni B_1(m), që përcaktohet nga parametrat gjeoelektrike të prerjes.

Në rastin më të përgjithshëm, që shqyrtohet, funksioni B_1(m) përcaktohet nga kushtet kufitare dhe, konkretisht, paraqitet si raport i dy përcaktorëve:

$$B_1\ (m) = \frac{\Delta\ B}{\Delta} \qquad (5)$$

ku: m — variabli i integrimit.

Përcaktorët e ekuacionit (5) varen nga karakteristikat gjeoelektrike të prerjes. Për të lehtësuar llogaritjet u përdorën dy polinomet e mëposhtme.

$$P_n(g) = \frac{\Delta\ B}{g^{\Sigma S_i}\ \pi\,(\rho_1 + \rho_1)} \qquad (6)$$

dhe

$$H_n(g) = \frac{\Delta - \Delta B}{g^{\Sigma S_i}\ \pi(\rho_{1+1} + \rho_1)} \qquad (7)$$

ku: $S_i = \frac{H_i}{H_o}$: $g = e^{-2mH_o}$; H_i — thellësia e tavanit të shtresës.

Duke i vendosur këto polinome në barazimin (5) mund të shkruajmë:

$$B_1(m) = \frac{P_n(g)}{H_n(g) - P_n(g)} \qquad (8)$$

Për përcaktimin e këtij funksioni u përdorën formulat rekurente të Flatosë. Nga këto formula rezulton se:

1. Polinomi $P_n(g)$ ka si koeficientë produktet e kombinacioneve me numër tek elementësh të pasqyrimit $K_{12}, \ldots, K_{(n-1)n}$ dhe si fuqi të g-së pranë koeficientëve shumën e diferencave të kombinacioneve korresponduese të $S_2, \ldots, S_n$.

2. Polinomi $H_n(g)$ ka ndërtim të ngjashëm me $P_n(g)$ por ka kombinacione me numër çift ekuacionesh.
p.sh. për prerjet pesështresore:

$$P_5(g) = K_{12}g^{S_2} + K_{23}g^{S_3} + K_{34}g^{S_4} + K_{12}K_{23}g^{S_4-S_5+S_2}$$
$$K_{12}K_{23}K_{45}g^{S_5-S_3+S_2} + K_{12}K_{34}K_{45}g^{S_5-S_1+S_2}$$
$$K_{23}K_{34}K_{45}g^{S_5-S_4+S_3}$$
$$H_5(g) = 1 + K_{12}K_{23}g^{S_3-S_2} + K_{12}K_{34}g^{S_4-S_3} + K_{12}K_{45}g^{S_5-S_2} +$$
$$+ K_{23}K_{34}g^{S_4-S_3} + K_{23}K_{45}{}^{S_5-S_3} + K_{34}K_{45}g^{S_5-S_4} +$$
$$+ K_{12}K_{23}K_{34}K_{45}g^{S_5-S_4+S_3+S_2}$$

Ku: $K_{i,i+1} = (\rho_{i+1} - \rho_i) / (\rho_{i+1} + \rho_i) +$ koeficientët e pasqyrimit.
Funksioni i emisionit P_n u llogarit me formulën:

$$q_N = \lim_{g \to 0} \frac{P_n(g) + \sum_{i=1}^{N-1} q_i g^i \, [P_n(g) - H_n(g)]}{g^N} \qquad (9)$$

Llogaritja e koeficientëve të polinomeve të $P_n(g)$ dhe $H_n(g)$ u suall në ndërtimin e kombinacioneve C^i_{n-1}, ku $i = 1, 2, \ldots n-1$
Gjithsejt llogariten $\sum_{i=1}^{N-1} C^i_{n-1} = 2^{n-1} - 1$ koeficiente. (Njëshi i polinomit $H_n(g)$ nuk duhet, prandaj s'e marrim parasysh). Për realizimin e ndërtimit të kombinacioneve në makinën elektronike u punua në mënyrën e mëposhtme:

1) Kemi n—1 elemente $E_1, E_2, \ldots, E_{n-1}$
2) Ndërtojmë kombinacionet e tipit C^i_{n-1}: $E_1, E_2, \ldots, E_{n-1}$
3) Supozojmë se janë ndërtuar kombinacionet C^{i-1}_{n-1}
4) Ndërtojmë kombinacionet C^i_{n-1},
kur $j = i, \ldots, n-1$ marrim elementin E_j dhe kombinacionet C^{i-1}_{n-1} të elementeve $E_1, \ldots E_{j-1}$,

Në këtë mënyrë ndërtohen kombinacionet e kërkuara. Në fig. 2 tregohet skema për prerjen pesështresore (n = 5).

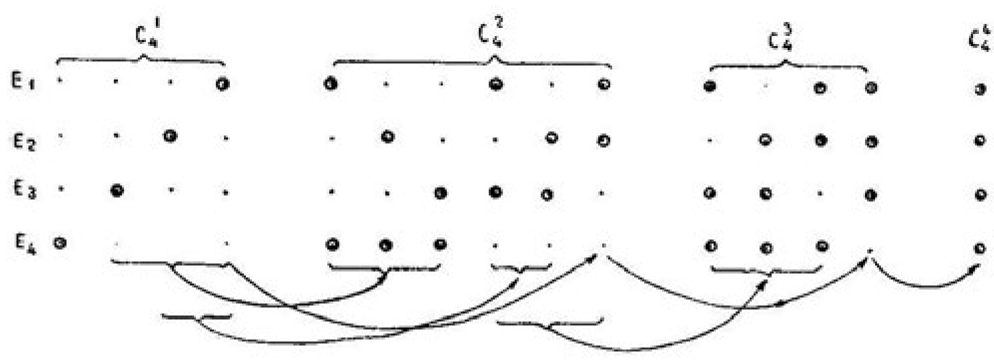


Figura 2

Për realizimin praktik të ndërtimit të kombinacioneve përdoren tre masivë numrash: PH, PH1, PH2 me nga $2^{n-1}-1$ elemente.
Elementet e masivit PH përfaqësojnë koeficientët e $P_n(g)$ dhe $H_n(g)$.
Elementët e PH1 përfaqësojnë indeksin j të elementit E_j, ndërsa elementët e PH2 përfaqësojnë fuqinë pranë g-së.
Për llogaritjen e q_N duhen vetëm PH dhe PH2. Në PH1 ruhet informacioni ndërmjetës që duhet vetëm për ndërtimin e kombinacioneve.
Në fig. 3 jepet paraqitja grafike e PH1.

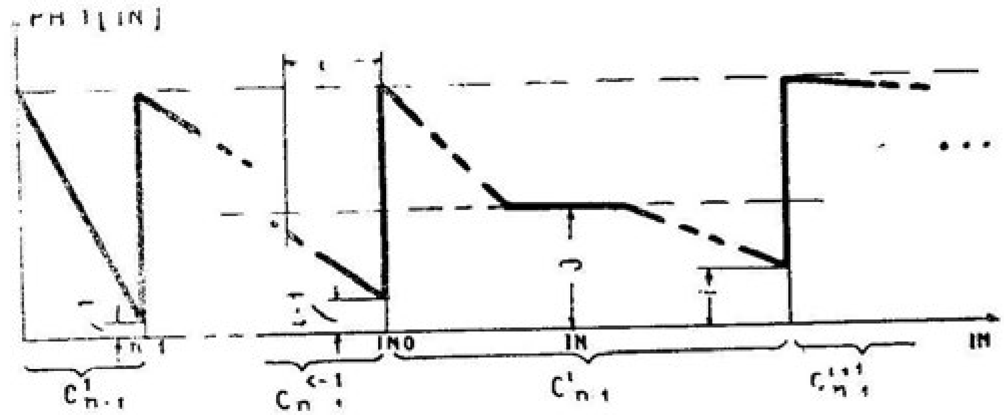


Figura 3

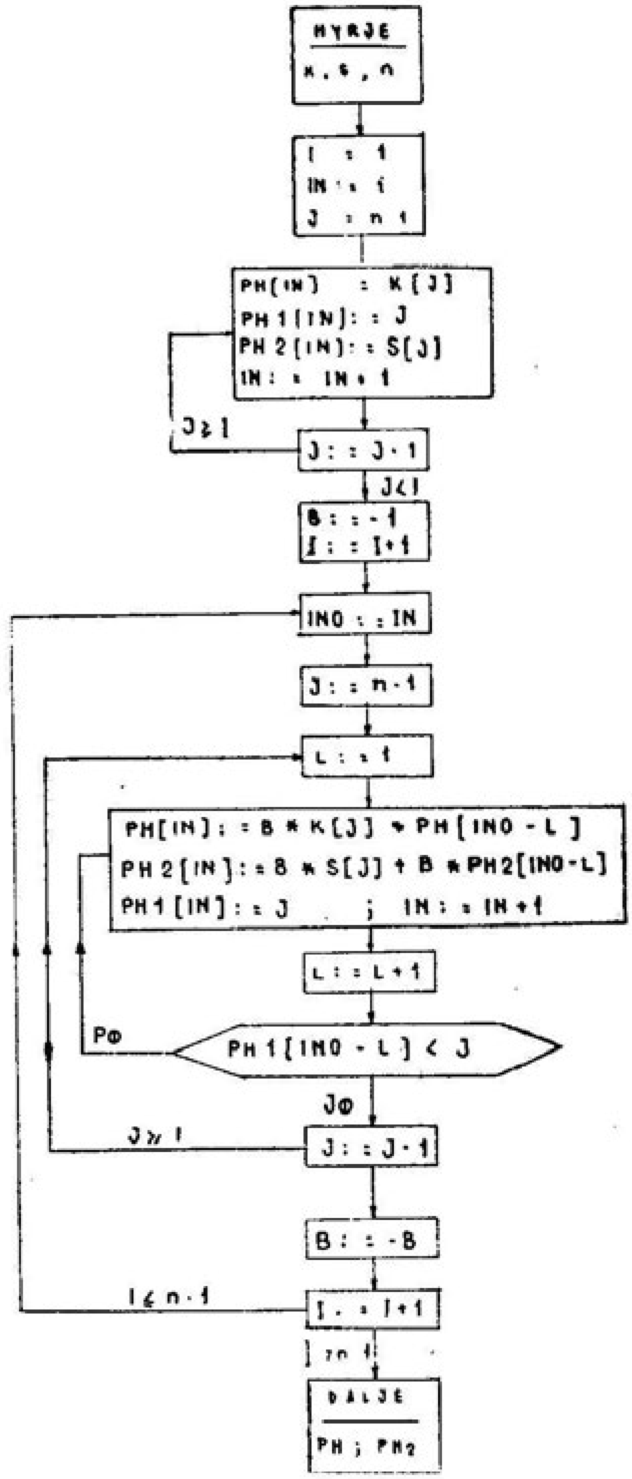
Duke i dhënë L-së vlera të ndryshme (1, 2, ...) dhe duke krahasuar **j** me vlerat e PH1 që i përkasin zonës C_{n-1}^{i-1} mund të fiksohen kombinacionet C_{n-1}^{i-1} të elementëve $E_1, E_2, \ldots E_{j-1}$ për të formuar C_{n-1}^{i-1} (duke u bashkuar me E_j. Llogaritja e PH, PH1, PH2 bëhet njëkohësisht hap pas hapi. Gjatë llogaritjes, termat e PH dhe të PH2, që u përkasin kombinacioneve me numër çift elementësh (d.m.th $H_n(g)$-së) u shumëzuan me -1 për të lehtësuar llogaritjen e q_N.
Si të dhëna fillestare për profilin n shtresor janë

$$K_{1,i+1} = \frac{\rho_{i+1} - \rho_i}{\rho_{i+1} + \rho_i} \quad i = 1,2,\ldots\ n-1$$

$$S_i = \frac{H_i}{H_0} \qquad i = 1,2,\ldots,n.$$

Më poshtë jepet bllokskema Nr. 1 për llogaritjen e PH dhe PH2;

BLLOK SKEMA Nr 1



a) Masivi K = ($K_{i,i+1}$), masivi S = (S_i) me nga n—1 elemente, pra K, S [1:n—1]

b) Masivet PH, PH1, PH2 [$1:2^{n-1}-1$]

Pas llogaritjes së PH dhe PH2 sipas bllokskemës Nr. 1 kalohet në llogaritjen e q_N.

Për rezervimin e q_N^{ve} në kujtesën e brendshme të makinës llogaritëse elektronike përdoret masivi Q[1:M]. Për të përcaktuar q_N sipas ekuacionit (9), në masivin PH gjenden termat e $P_n(g)$ pranë g^N (duke krahasuar N me PH2 [i])dhe termat e $P_n(g) - H_n(g)$ pranë g^{N-1} (po duke krahasuar N—i me PH2 [i]).

Për dallimin e termave të $P_n(g)$ nga $H_n(g)$ është përdorur shenja e PH2 (nqs PH2 [i]<o atëhere termi përkatës PH [i] i përket $H_n(g)$ dhe në qoftë se PH2 [i]>0 atëhere ai i përket $P_n(g)$.

Gjithashtu, termat e PH i përkasin $H_n(g)$ janë shumëzuar me —1 paraprakisht. Si të dhëna fillestare për llogaritjen e q_n janë:

a) Masivët PH dhe PH2 të llogaritur paraprakisht me bllokskemën Nr. 1.

b) Numri i përgjithshëm i q_N-ve, pra M

c) $S_n = \frac{H_n}{H_o}$ (veçse $n \neq N$).

Duhet kujtuar gjithashtu se S_n = S [n—1]

Më poshtë jepet bllokskema Nr. 2 për llogaritjen e q_N.^{e}

Me mbarimin e llogaritjeve të q_n^{ve} sipas kësaj bllokskeme fillon llogaritja e kurbave të sondimeve sipas ekuacionit (2).

Të dy blloskemat, parimisht mund të përdoren për prerje me çfarëdo numër shtresash, por duke u nisur nga kapaciteti i kujtesës së makinës X-2 mund të kryhen llogaritjet për prerje me një numër shtresash brenda dhjetëshes së parë. Deri tani e kemi përdorur këtë program për prerje trishtresore.

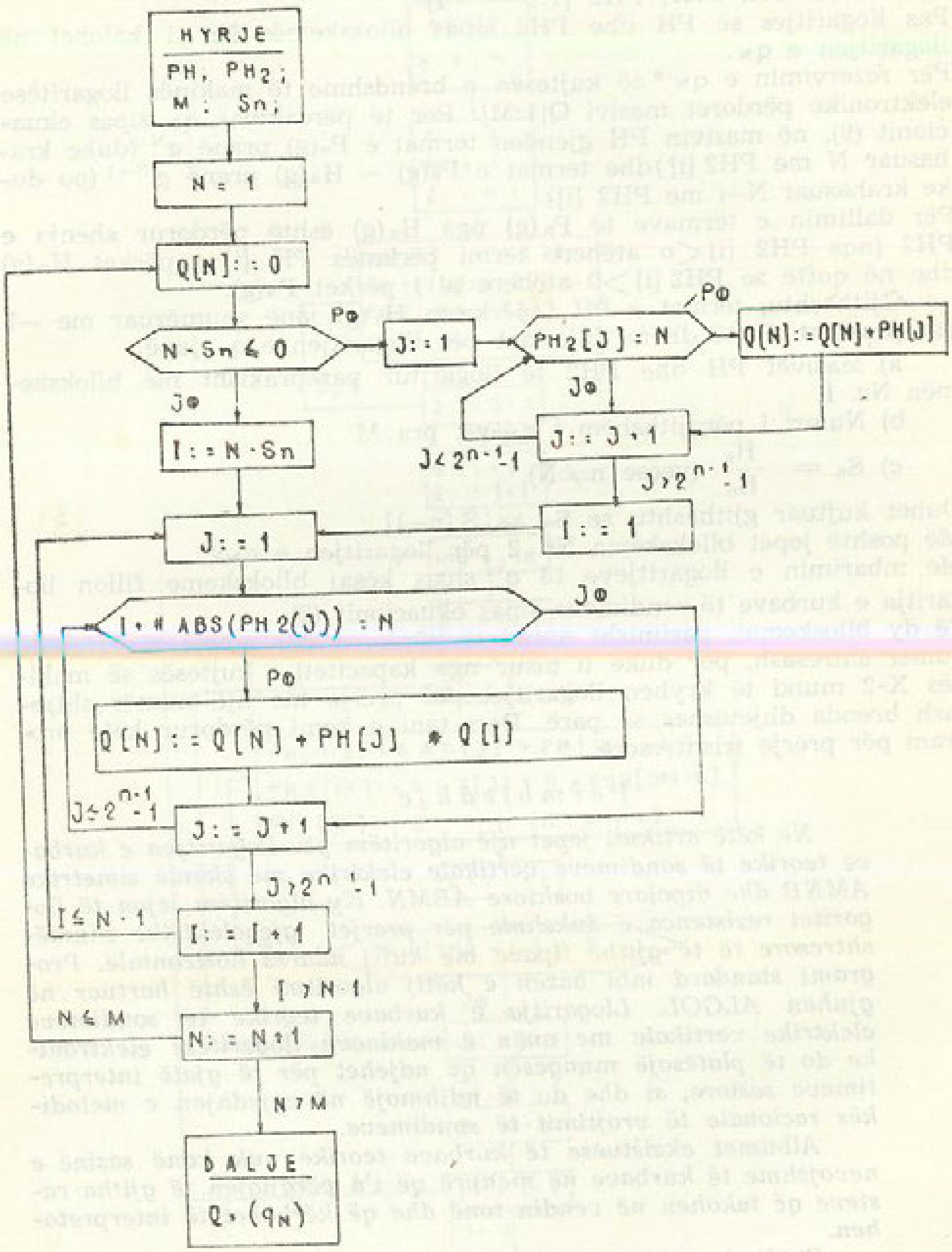
Përmbledhje

Në këtë artikull jepet një algoritëm për llogaritjen e kurbave teorike të sondimeve vertikale elektrike me skemë simetrike AMNB dhe dipolare boshtore ABMN. Ky algoritëm lejon të llogaritet rezistenca e dukshme për prerjet gjeoelektrike shumështresore të të gjithë tipave me kufij ndarës horizontalë. Programi standard mbi bazën e këtij algoritmi është hartuar në gjuhën ALGOL. Llogaritja e kurbave teorike të sondimeve elektrike vertikale me anën e makinave llogaritëse elektronike do të plotësojë mungesën që ndjehet për të gjatë interpretimeve sasiore, si dhe do të ndihmojë në zgjedhjen e metodikës racionale të vrojtimit të sondimeve.

Albumet ekzistuese të kurbave teorike nuk kanë sasinë e nevojshme të kurbave në mënyrë që t'u përgjigjen të gjitha rasteve që takohen në vendin tonë dhe që kërkohet të interpretohen.

Studimin e këtij problemi e shohim edhe si pjesë të domosdoshme për zgjidhjen e detyrës së zhdrejtë të elektrometrisë me anën e makinave llogaritëse elektronike, d.m.th. të përcaktimit të parametrave të prerjes gjeoelektrike sipas kurbave të vrojtuara.

BLLOK SKEMA Nr 2



Deri tani me programin e hartuar kemi llogaritur kurbat e prerjeve trishtresore dhe po vazhdon puna për prerjet me më shumë shtresa.

(Paraqitur në Redaksi më 23.10.1978)

Katedra e Gjeofizikës
Qendra e Matematikës Llogaritëse

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Résumé

UN ALGORITHME
POUR CALCULER LES COURBES THEORIQUES
DES SONDAGES ELECTRIQUES VERTICAUX

Les auteurs donnent, dans leur exposé, un algorithme pour calculer les courbes théoriques de sondage vertical électrique au moyen des calculateurs électroniques. Le programme standard sur la base de cet algorithme est fait en langue Algol pour les coupes géo-électriques à plusieurs stratifications, aux limites de séparation horizontales. Il est valable pour les sondages à schéma symétrique AMNB et à schéma dipolaire axial ABMN.

La programmation a été faite sur la base de la solution connue de l'équation de Laplace:

$$\frac{\partial^2 u}{\partial r^2} + \frac{1}{r}\frac{\partial u}{\partial r} + \frac{\partial^2 u}{\partial z^2} = 0, \qquad (1)$$

laquelle, pour les coupes à plusieurs stratifications a la forme:

$$\rho_d = \rho_1 \left[1 + 2 \sum_{n=1}^{\infty} q_n f_s \right] \qquad (2)$$

où ρ_1 — la résistance électrique spécifique de la première couche;
q_n — la fonction de l'émission dépendant des paramètres de la coupe géo-électrique;
f_s — la fonction dépendant du genre et des dimensions du schéma.

La fonction de l'émission q_n a été calculée en partant de la fonction B_1 (m), déterminée par les paramètres géo-électriques de la coupe, pour le calcul de laquelle on a employé les formules recourantes de Flateau.

La fonction q_n a été déterminée par la formule:

$$q_n = \lim_{g \to 0} \frac{\sum_{i=1}^{N-1} q_i g_i [P_n(g) - H_n(g)]}{g^n}$$

où $g = e^{-2mHo}$

Ho — la masse commune des profondeurs des couches;

m — la variabilité de l'intégration

$P_n(g)$, $H_n(g)$ — les polynômes dépendant des paramètres géo-électriques de la coupe.

Dans l'article sont donnés les deux blocs de schémas pour le calcul de la fonction q_N, qui peuvent être faites valoir pour la coupe avec un nombre quelconque de couches, mais, en partant de la capacité de rappel de la machine peuvent être effectués des calculs pour la coupe avec un nombre de couches à l'intérieur de la première décennie.

Avec la fin du calcul q_N commence le calcul des courbes de sondage d'après l'équation (2).

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ON THE APPLICATION OF GEOPHYSICS IN THE EXPLORATION FOR COPPER AND CHROME ORES IN ALBANIA

Alfred FRASHËRI, Ligor LUBONJA and PËRPARIM ALIKAJ

In this paper some generalized results of geophysical exploration for copper sulphide and chromite ores in Albania are presented. The most important geophysical methods used are electrical prospecting , gravity, magnetics and electromagnetics. Physical properties of the ores, genesis and geological problems to be solved have determined the proper choice of any of these methods in the complex exploration.

INTRODUCTION

The copper and chrome ores in Albania, as well as other solid minerals, oil and gas included are explored through a wide complex of geophysical and geochemical methods.

The contribution of geophysical methods in mineral exploration has been in the search for ore bodies or mineralized zones and in geological mapping.

Electrical prospecting and sometimes magnetics, EM or gravity have been the main methods in the search for copper sulphide deposits. Depth exploration up to 600-700m have been proved with Induced Polarization (IP) method.

Chromite ores have been explored through the gravity, magnetics and Induced Polarization method. Many good results have been obtained but in comparison with copper exploration, the chromite is more complicated and more problematic.

1. PHYSICAL AND GEOLOGICAL BASES FOR GEOPHYSICAL EXPLORATION OF COPPER AND CHROME DEPOSITS

The copper ore deposits in Albania are mainly connected with ophiolitic belt of Mirdita zone. Mineralization is presented by sulphides as pyrite and chalcopyrite located in volcanogenic rocks (diabase-spilite-keratophyre), in effusive rocks of volcano-sedimentary formations and by quartz-sulphides in gabbro rocks. The mineralization in volcanogenic media forms concentrated ore bodies or simply disseminated sulphide zones or both. The mineralized zones range from some meters to some hundred of meters wide and from some tenths of meters to kilometres in strike. Massive or veinlet ore bodies

are often present inside these mineralized zones. In volcano-sedimentary formations mainly massive ore bodies are found.

In table 1 are given the results of a petrophysical study of copper sulphide ores and surrounding rocks (Avxhiu, 1979, Frasheri et al 1986, Alikaj 1989). Several hundreds of examples have been tested for every physical parameter included in the study.

The most typical and distinctive physical properties are chargeability and resistivity which are conditioned by mineral content, structure and degree of rock alternation. The surrounding rocks are characterized by low value of chargeability and higher resistivity than sulphide ores.

The sulphied ores have greater density than the surrounding rocks and when they contain pyrrhotite and/or magnetite they present magnetic properties.

These four properties serve as bases for the application of IP, resistivity, EM, self-potential and mise-a-la-masse in exploration of copper deposits. Occasionally, magnetic and gravity have been used, too.

As regards to the chrome ore deposits, they mainly are linked to the upper part of hartzbourgite-dunite tectonite sequence, as well as with lower part of dunite cumulate sequence of ultramaffic massifs. The most of chromebearing is of podimorf type and less stratiform.

Dunites and hartzbourgites are often serpentinized and contain secondary magnetite in fine grained disseminated form or thin veinlet.

These ore bodies are presented by rare up to dense disseminated, nodular, belted or massive chromites. The type of ore is chromespinelid, mainly magnezial and sometimes ferrous. Its chemical composition is simple and the content of olivine and serpentine is different. In some cases the chromite grains are enclosed by secondary magnetitie membrans, which are crystallized as a result of intensive dynamic processes. Secondary magnetite is present in chromite ore serpentine as well.

In table 2 are presented the physical properties of different kinds of chrome ores and ultramaffic rocks (Frasheri 1974; Lubonja and Frasheri 1966).

The chrome ore density is determined by the content of Cr2O3 and in general, for a simple case the following dependence is observed:

ϱ = 40ùX+2000 in Kg/m3

where ϱ - ore density

X - percentage of Cr2O3 in ore

This dependency is not unique, because the ore density is dependent on the degree of serpentinization of its olivine and on microfissures as well.

Intense chargeability values are characteristic of chromites which contain secondary magnetite in veinlet or network type. Because of chemical and thermal remnant magnetization, some chromite ores are magnetic.

The petrophysical properties of ultramaffic rocks are mainly subject to their serpentinization degree and their physical and mechanical conditions. According to table 2 the following conclusions can be drawn:

1. Density is the most stable and typical property to discriminate between chromite ores and ultramaffic rocks, so the gravity is the basic method to be used in our chrome exploration.
2. The values of geophysical anomalies over ore bodies are depended on physical contrast between chromites and surrounding rocks.
3. Sometimes physical property contrast between chromite and ultramaffic rocks is very low, so no geophysical anomaly of this parameter could be observed.
4. Over some parts of ultramaffic rocks, some geophysical anomalies can be fixed, due to physical property contrast with surrounding rocks.

Based on uppermentioned conclusions we can state that geophysical anomalies present some targets which on a certain probability, show for the presence of chrome ore bodies. Their lack shows only that up to the depth of investigation do not exist ore bodies with property contrast with ultramaffic rocks. In this way, the geophysical exploration of chrome ore is rather complicated so, a wide integration of geological, geophysical and geochemical methods should be used.

2. GEOPHYSICAL EXPLORATION FOR COPPER ORE DEPOSITS

During the sixties, the main Electrical Prospecting method in copper exploration in Albania has been Self-Potential (SP). Resistivity and Magnetic surveys have been carried out, too. Occasionally, the Gravity method has been used. Good results have been provided through this geophysical integration for shallow depth, some tenths of meters (Fig. 1) (Frasheri 1963).

After rapid development of IP methods in early seventies, it turned out to be the major surveying method for copper sulphide exploration, while the others served as complementary or follow-up methods. In this period the depth of investigation has increased up to 200 m (Fig. 2) (Avxhiu 1979).

In the last decade our copper exploration was extended to greater depths, up to 400-700 m. For this purpose we have worked in different ways:

1. New IP instrumentation with high power transmitter and high sensitivity receiver was used (IPC-7/15KW, IPR-10A, IPR-11, SCINTREX).
2. It were studied theorically and experimentally the surface-to-hole IP responses to investigate the ore bodies around the boreholes, especially at great depths (Lubonja et al 1985; Frasheri, Avxhiu and Alikaj 1990).
3. The possibily of separation of low amplitude and frequency IP anomalies was sudied (Lubonja et al 1984).
4. A good coordination between direct mineral exploration and geological mapping with geophysical methods has been applied (Avxhiu, Bushati and Alikaj 1984).

In theorical studies were included the investigations of IP field distribution in heterogeneous geological media, with curved boundary, over

mountain relief. Using the finite element method and other techniques were developed the proper algorithms and were compiled some programme packets for the computation of synthetic IP anomalies (Frasheri, Tole and Frasheri 1984; Frasheri 1987; Frasheri 1989; Likaj and Alikaj 1989; Frasheri, Avxhiu and Alikaj 1990).

Mathematical models were computed for polarizable bodies of any geometrical shape, with or without resistivity contrast, in 3-D, 2 1/2-D, 1/2-D and 2-D. The current electrode could be set on surface or underground.

As a result of theoretical and experimental studies in the different geological media the depth of investigation of IP method in copper sulphide exploration have increased markedly, up to 600-700 m. In Fig. 3 is presented such a case in volcano-sedimentary formation in the Northeastern part of Albania. Survey was carried out using deep IP soundings with a maximum separation of AB=4400 m.

Chargeability responses for every separation are plotted at points located at the approximate depth of investigation Hi. The geological data are plotted on the same section, also. This type of presentation is called a "real section" (Alikaj 1989; Langore, Alikaj and Gjevreku 1989). Chargeability contours shows an anomaly at a depth of 500-700 m, which after the performance of boreholes confirmed a thick sulphide zone at this depth. The shallow chargeability anomaly is connected with the contact zone between ultrabasic and amphibolite rocks, which contain magnetite and scattered sulphides.

Another important problem of IP method is to discriminate between high grade and low grade sulphide ores. Recently, Spectral IP parameters are being investigated (Alikaj 1989; Langore, Alikaj and Gjevreku 1989). We have used Cole-Cole (Pelton et al 1978) model in time domain to derive the synthetic Spectral IP parameters "m", "ç" and "C", according to Johnson (1984).

The study of Spectral IP parameters was carried out in samples, in test sites and in field conditions. The main conclusion of the study was the good discrimination between massive or veinlet sulphide ores and disseminated ones. In Fig. 4 is presented a field case history of Spectral IP survey in Derveni volcanogenic rocks. Within the chargeability "real section" of M4 window, an intensive apparent time constant (ç) anomaly was fixed. The first borehole drilled near this section intersected a thick mineralized zone with some intervals of concentrated sulphide belts. However the centre of the anomaly is not yet verified.

3. SOME RESULTS AND PROBLEMS IN CHROME EXPLORATION WITH GEOPHYSICAL METHODS

The geohysical investigation, consisting of Gravity, Magnetic, Resistivity and Induced Polarizatoin methods has proved good results in supporting the geological mapping of ultramaffic rocks and their relationships with surrounding formations, in cognition of geology of the mineralized belts and

primary textures of rock massifs (Frasheri 1974, Langore et al 1989). In this paper we present some results of chrome exploration.

Over the ore bodies weak gravity anomalies are fixed, which are more evident after the transformations of the gravity field. In Fig. 6 is presented such a case from north-east Albania (Frasheri 1974). It is to be noticed that such anomalies are also caused by fresh rock isolations settled among serpentinized rocks. Magnetic survey may help in some cases to solve this problem. Based on the orientation of magnetization axis of the ore body and the magnetic property contrast, the magnetic anomalies can be negative or positive (Figs. 5 and 6, Lubonja and Kosho 1974, Frasheri 1974). Positive magnetic anomalies have been also recordered over the magnetic serpentinites which contain secondary magnetite due to dynamometamorphism. But these cases differ from those of ore bodies because of the lack of gravity anomalies.

In many cases there are fixed IP anomalies over ore bodies, consisting of polarizable chromite (Fig. 7, Lubonja and Frasheri 1966). These anomalies are often wider than ore bodies because of a dunitic envelope which presents the same IP parameters as chromite ore. In some cases IP anomalies are caused by polarizable ultramaffic rocks, too. Some laboratory tests of chromite samples with Spectral IP have shown no correlation between Cole-Cole parameters and chromebearing.

In our practice of chrome exploration we have cases where the distribution of physical fields is very complicated, because the ultramaffic rocks are very heterogeneous. In these cases, the "ore" anomalies may be detected using a wide integration of geophysical and geological methods. However, the complicated physical fields render more difficult the data interpretation and decrease their reliability.

To increase the depth of exploration of chromite ores we have successfully used the borehole magnetic survey and hole-hole radiowave method (Fig. 8, Gjevreku 1986). The boreholes S-17 carried out in this section did not intersected any ore body. From vectorial magnetic survey in this hole, an anomal sector of total vector of magnetic field (T) at depth 190-330m was fixed. This anomaly was interpreted as linked to a magnetic chromite ore body between the boreholes S-17 and S-16. The shallow boreholes S-1, S-2, S-3 and S-4, carried out from the mine working G5 intersected the predicted ore body.

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LIST OF CAPTIONS

Fig. 1. Geophysical profiles and geological section of a copper sulphide ore deposit.
1. Ultrabasic rock. 2. Argillaceous schists. 3. Diabase. 4. Massive ore body. 5. Gossan. 6. Tectonic faults

Fig. 2. Geophysical and geochemical profiles over the cross-section of a copper sulphide ore deposit.
1. Overburden. 2. Keratophyre rocks. 3. Spilites. 4. Disseminated sulphides. 5. Massive sulphide ore body.

Fig. 3. "Real-section" of chargeability parameter (Ma) according to the VES-IP measurements in volcano-sedimentary formations.
1. Overburden. 2. Ultrabasic rocks. 3. Amphibolites. 4. Volcano-sedimentary rocks. 5. Limestones. 6. Disseminated and veinlet sulphides. 7. Chargeability contours in mV/V. 8. Center and the number of VES-IP.

Fig. 4. "Real-section" of chargeability (M4) and apparent time constant Spectral IP parameter (ç) over a mineralized sulphide zone.

Fig. 5. Gravity and Magnetic profiles over a chromite ore body.
1. Overburden. 2. Hartzbourgites. 3. Dunites. 4. Chromite ore.

Fig. 6. Geophysical profiles and geological section over a chromitic ore deposit.
1. IP profile. 2. Resistivity profile. 3. Vertical component of magnetic field profile. 4. Hartzbourgites. 5. Dunites. 6. Chromite ore. 7. Gradual geological boundary. 8. Overburden. 9. Mine working.

Fig. 7. IP and resistivity profiles over a cross-section of a chromitic ore deposit.
1. IP profile. 2. Resistivity profile. 3. Massive chromite. 4. Disseminated chromite. 5. Hartzbourgites. 6. Dunites. 7. Tectonic fault.

Fig. 8. Results of a borehole three component magnetic field survey in search for chromite ores. (Total magnetic field T).

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OUTLOOK OF IP ANOMAL EFFECT OF A BODY SETTLED IN THE ELECTRIC FIELD OF AN UNDERGROUND POINT CURRENT ELECTRODE

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Abstract

The borehole underground IP survey presents one of the main directions to increase the depth investigation of Electrical Prospecting for copper ore deposits. The IP anomal effects are strongly increased when the current source is settled close to the underground polarizable ore bodies. Moreover the outlook of spatial distribution and the intensity of this effect are quite different in comparison with cases when current electrodes are settled into earth's surface.

Through mathematical modeling and checking up the experimental results in physical models in laboratory and in situ, over the known geological conditions, the study of this effect is presented. The measurements were carried out with IPR- 10A, IPR-11 receivers and IPC-7/15 KW transmitter (SCINTREX) in Time Domain. The models have been carried out for any geometrical body shape with the same resistivity as surrounding medium. One of the current electrodes was placed underground, in borehole or mine works, while the other one, on the surface. Calculation of Bleil's integral has been performed utilizing some notions of the finite element method.

From the modeling has been defined that IP anomaly is accentuated many times when one of the current electrodes is placed underground, against the ore body, in comparison with the case when this electrode is situated on the surface. This is particularly evident for bodies at great depth (600-800)m.

1. Introduction

Albanides are part of the Mediterranean Alpine orogenic belt. Those extend in Albanian's territory and are placed between Dinarides and Helenides. The ophiolites are one of the most important elements of this belt, covering a territory of 2600 km. Within ophiolites a lots of chrome and copper ore deposits are found. Their exploration in Albania has reached up to 1000 m deep and more. The increasing of depth exploration from 200-300m up to 600-800 m through geophysical prospecting has become a necessity in Albania.

One of ways to reach such a great depth exploration in electrical prospecting is the studying of the anomal effect of IP method setting one or both current electrodes in boreholes. Through such settlements the current source approaches to the ore body and IP effect is obviously increased.

To investigate this kind of IP surveys we used the mathematical models. For measurements in terrain, powerful transmitters and high sensitivity receivers were necessary, so we used IPC-7/15Kw

transmitter and IPR-10A and IPR-11 receivers (SCINTREX). The last one permitted us to obtain spectral IP parameters as well (Alikaj P. 1989).

The same instrumentation was used in IP electrical soundings (IP-ES) with long spacing (up to AB=4,400m), results of which were coordinated with hole-hole or hole-surface arrays.

2. Mathematical modeling

Mathematical models for anomalous effects of resistivity and IP are carried out using different ways and algorithms. Das V.C. and Parasnis D.S. (1987) have used the solutions of Fredholm's integral equation of the second kind. The results are presented for a dipole-dipole array. Eskola L. et al., (1984) have done their modeling in the Frequency Domain. The integral in this case is solved by means of the method of subsections.

But the modeling of anomalous effects for the surveys with underground arrays begin with the study of Waag D.M. and Seigel H.O. (1983) where beside the mathematical models the results of field surveys are given. For these models there are papers from Komarov V.A. (1972) and Draskovits P. and Simon A. (1992).

In order to fulfill the demands of the development of prospecting for copper ore deposits situated at great depths up to several hundred meters we realised another mathematical modeling for the anomalous effects of IP in the time Domain ~y using the method of finite elements, or even only its principles. This modeling was done for surveys with gradient array.

The mathematical modeling was carried out to study the anomal effect of IP caused by ore bodies of any geometrical shape.

The ore body was supposed to have the same electrical resistivity (o) as the surrounding rocks. Such ore bodies are for example disseminated sulphides or chromites, which contain secondary magnetite. These ores have a volume polarizability higher than the surrounding rocks. Chargeability has a value n. The relief was supposed to be flat. One of the current electrodes is situated underground in the point A with coordinates (X, Y, h) at a depth h from the surface. The other electrode is settled at point B (X, Y, 0) on the surface. The IP anomal effect was analyzed by determining the potentials of the IP electrical field and the polarizable field in the points M and N which are moved on the surface (Fig. 1).

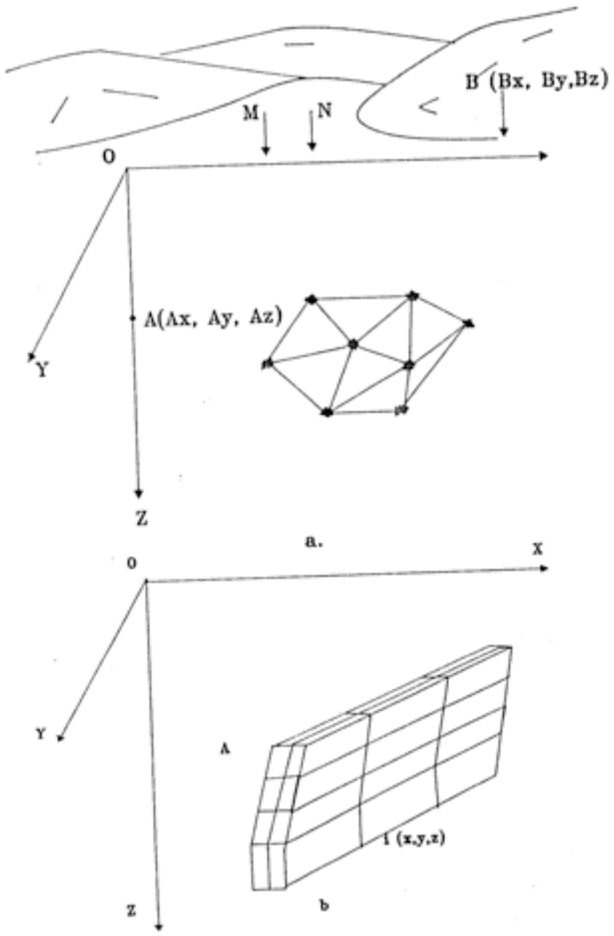


Fig. 1

Fig 1. 3-D geoelectric model of a target of a random geometrical shape (a), and of a prismatic body with a random section (b).

The induced polarization effect Uip is calculated with the well-known formulae (Bleil D., 1953; Seigel H.O., 1959):

$$U_{IP} = C\int_V \nabla U . \nabla \frac{1}{R} dv \tag{1}$$

Where:

Uip - the potential of induced polarization field,

Uo - the potential of primary electric field,

U=Uo+Uip - the potential of resultant electric field,

R - the vector from body point to measurement point,

C - a constant value determined by electric properties of medium.

For the 3D models, because we considered that the ore body and surrounding rocks have the same electrical resistivity, the integral depending from U_0 can be calculated directly by discretizing the surface of the body with small elements. In the 2D case, when the chargeability is a voluminous one, the finite element method, as well as ∇ Uo and the vector of chargeability C∇ Uo calculate the potential Uo.

It is known that in field conditions of electrical survey we have Uip<<Uo, so we accepted the simplification proposed by Bleil D. (1953) as well as the evaluation made by Komarov V.A. (1972) assuming that:

$$CU \approx CUo \qquad (2)$$

Following this assumption the calculation of Uip was reduced to the calculation of the integral (1) in which the potential Uo of primary electric field has replaced the potential U. More concretely, for the selected model Uip was calculated with the formulae:

$$U_{IP} = C \int_S \frac{1}{R} \frac{\partial Uo}{\partial n} dS \qquad (3)$$

Where n is the unitary vector, perpendicular to the surface S of the body and oriented towards outside.

The primary field potential Uo created by the current from the deep electrode A, surface electrode B and virtual source A+ with coordinates (X_A, Y_A, -h) (to take into account the influence of the earth surface on the scattering of the electrical field), was calculated with the formulae:

$$U_o = U_A + U_{A+} - U_B = \frac{\varrho I}{4\pi}(\frac{1}{R_A} + \frac{1}{R_{A+}} - 2\frac{1}{R_B}) \qquad (4)$$

Where R_A, R_A, R_{A+} - the distances from the electrodes A, B and the virtual source A+ to the point where the potential is calculated. To solve the problem, in the integral (3) we did the replacement:

$$\frac{\partial U_o}{\partial n} = -E_o = \frac{\varrho I}{4\pi}\left(\frac{R_A}{R_A^3} + \frac{R_{A+}}{R_{A+}^3} - 2\frac{R_B}{R_B^3}\right) \qquad (5)$$

where:

$C_0 = \dfrac{\varrho I}{4\pi}$ - in Volt. meter (o - in Ohm.m, I - in Amper).

After the replacement (5), the integral (3) takes the form:

$$U_{IP} = C_o \int_S \frac{1}{R}(\frac{R_A}{R_A^3} + \frac{R_{A+}}{R_{A+}^3} - 2\frac{R_B}{R_B^3})dS \qquad (6)$$

In the program POLARELF-B the integration is carried out numerically. We considered the surface S as a collection of triangular elements and for each element we used the Gauss integration method, representing the integral (6) as a double sum:

$$U_{IP} = C.C_0.\sum_e \sum_i \frac{1}{R} \vec{n} \left(\frac{R_A}{R_A^3} + \frac{R_{A+}}{R_{A+}^3} - 2\frac{R_B}{R_B^3} \right) W_i \quad (7)$$

Where:

$W_i = \frac{D_T}{3}$ - the Gaussian integration weight of the integration point "i";

D_T - the surface of the element "e", for the triangular one being as one half of the vectorial product of two edges of the element;

R - the distance from the integration point to the measurement point.

$\vec{n}$ - the unitary vector n, for each element it was determined as a vectorial product of two edges of the element.

R_A, R_B, R_{A+} - the distances from the electrodes A,B and the virtual source A+ to the integration points. The coordinates of the later points for the triangular element were taken as:

$$X = i_1.P_1 + i_2.P_2 + i_3.P_3$$

$$Y = j_1.P_1 + j_2.P_2 + j_3.P_3$$

$$Z = k_1.P_1 + k_2.P_2 + k_3.P_3$$

Where:

i_1, j_1, k_1, i_2, j_2, k_2, i_3, j_3, k_3 - the coordinates (x,y,z) of the 3 nodes of the triangular element;

P_1, P_2, P_3 - the surface coordinates of the Gaussian integration point (Zienkiewicz O., 1980).

By means of cubic splines we calculated the intensivity ***Ipp*** of the induced field during the profile X.

The anomalous effect of the coefficient of IP was calculated as:

$$\mathrm{I} = \frac{Epp}{Eo + Epp} \cdot 100\% \quad (8)$$

On the basis of this algorithm, for each of two targets shown in fig.1, we developed two programs POLARELF-B and POLARPRIZ-2 in BASIC (Frashëri A., 1987; Frashëri A. et al., 1987). For a prismatic 2D target we used another algorithm used on the 2D finite elements writing the program POLARELF-F in FORTRAN77 (Frashëri A., 1987). In this program we used a new empiric constant C' instead of Co to take into account the 2D modeling of the 3D problem. The programs POLARPRIZ-2P and POLARPRIZ-3P are specialized for models 2.5D if a prismatic body with a random cross-section for the cases when one or the two electrodes are situated on the ground.

Calculating the anomalous effect of a polarized prism with section 4x4 units tested the programs POLARELF-F and POLARPRIZ-2. Conventionally we accepted the constants C'=Co=l. The potential was calculated during a profile over the edge of the prism. In this profile the source electrodes A,B are situated in a distance of 11 units from each other. In the fig.2 there is shown the same anomaly

calculated with the program POLARPRIZ-2, compared with calculations done by means of theoretical formula (the case of a homogeneous electrical field):

$$\overset{an}{Epp} = \frac{1}{4\pi} \cdot \frac{\eta_m}{1-\eta_m} \cdot E_0 \cdot \int_S d\Omega$$

Where:

$\eta_n = 4nC$ - chargeabilities of the prismatic body and the surrounding rocks,

E_0 - primary electrical field,

Ω - the angle in which the surface of the body is seen from the measurement point.

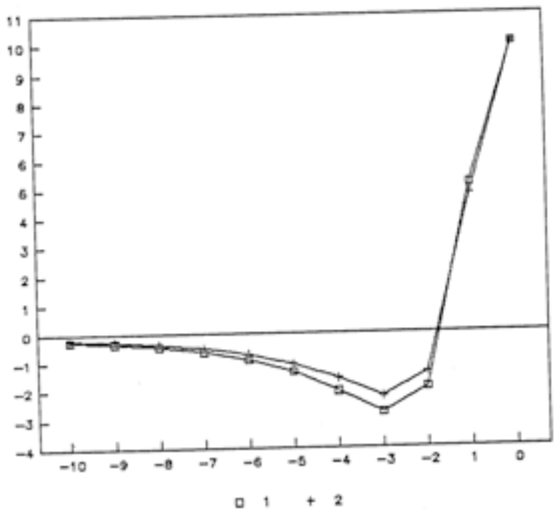


Fig 2. The results of the program POLARPRIZ-2 compared with the results obtained by means of a theoretical formula. 1 - the anomaly calculated by POLARPRIZ-2; 2 - the anomaly calculated by theoretical formula.

3. On the laboratory physical modelling

The physical modelings were carried out in a 2D medium, consisted of a shallow horizontal tank (1500*1000*10 mm) filled with tap water (Alikaj P. 1989). As models the thin chalcopyrite prisms were used. The following likeness criterion was applied in modeling:

$$P = \frac{S}{H} = Const$$

where:

S - the section surface

H - the top depth of ore body

A time Domain transmitter, type CTU-2 (IP module) and the IPR-10A receiver, with T=t=2 sec were used in these measurements.

4. The analysis of model results

The placement of one of current electrodes on the ground defines the view of scattering of the primary electrical field and the spatial position of IP vector as well (fig.3). As a result, the amplitude of anomalous effect of IP and its configuration should be conditioned by this field scattering.

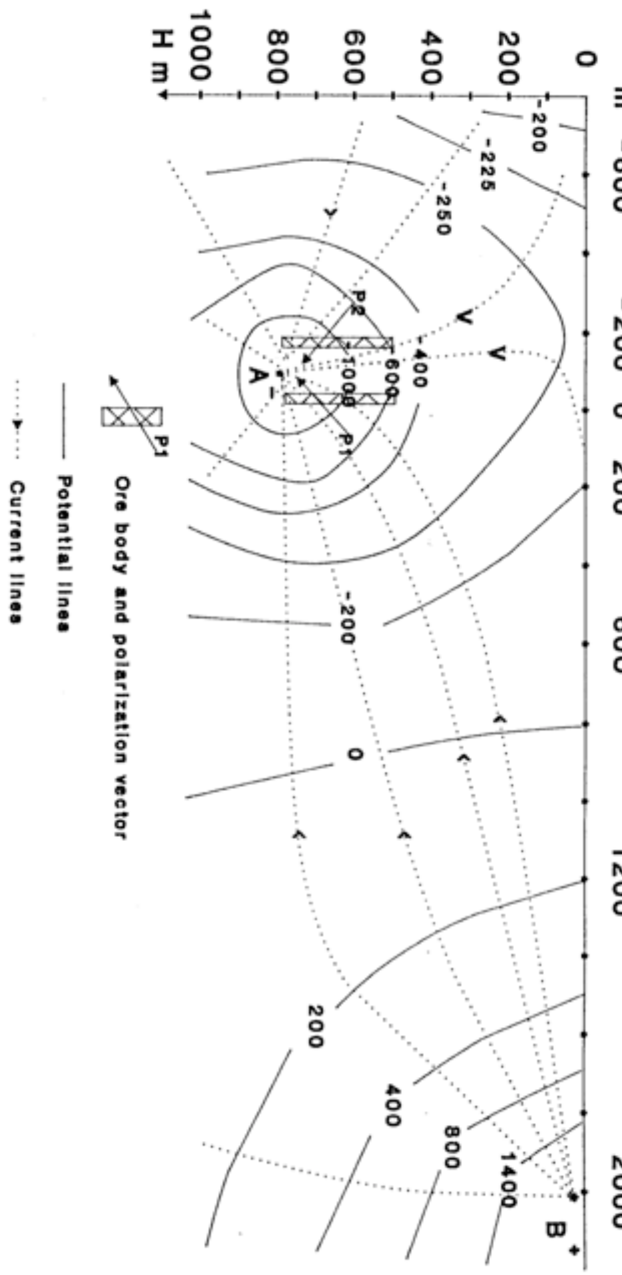


Fig 3. The normal electric field of an array with current electrode A placed on the ground. 1,2 - are potential lines; 3 - current lines; 4 - target and polarization vector.

When one of the current electrodes (A) is placed in front of ore body the IP anomal effect is amplified (fig.4).

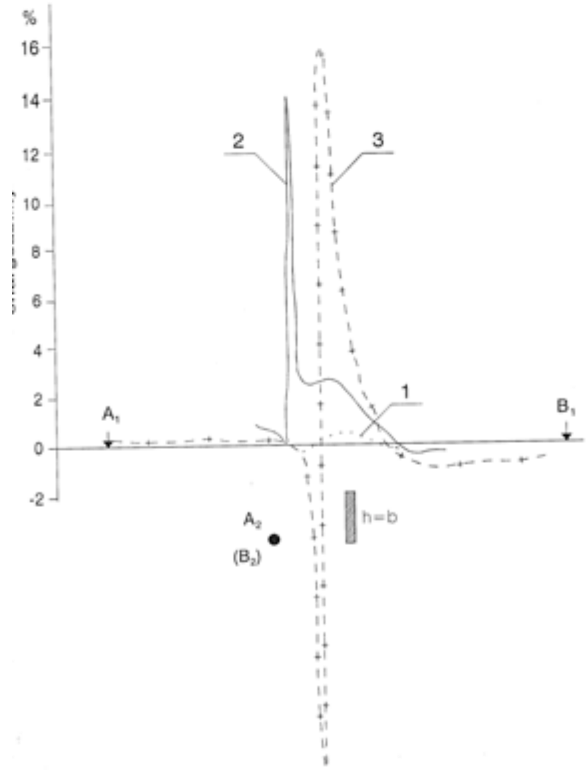


Fig 4. The IP calculated anomaly using POLARPRIZ-2P program over a polarizable prismatic target, with underground current electrodes. The IP plot is calculated for arrays: 1 - A B; 2 - AB; 3 - A B .

The configuration of anomaly is depending on the position of the electrical array in relation with ore body. The anomaly is more clear when the target is placed between the current electrodes A and B. A "spurious" point could result when the potential dipole is placed at the point on the around where the equipotential contour is tangent with the surface, so the primary voltage (Up) becomes zero. Because m=Uip/Up, in this point m→∞. The results of physical modeling are shown in fig.5. It is clearly seen that they are a good proof for the results of mathematical modeling.

The position of current electrode A in relation with the target determines the anomaly amplitude (fig.5,6). The highest amplitude is observed in cases when current electrode A is placed in front of the middle of the target and the lowest ones when this electrode is on both edges of the target. Based on this fact a methodological conclusion may be drawn: the measurements should be carried out for different depths of the current electrode in borehole, because the optimal depth of the target is not known. If the underground electrode is situated in face of the middle of the target, but in variable distances from it (the positions 3,4 of the electrode), it is seen that there are anomalies and for considerable distances from the target, about 300m for the given model, or until the ratio 1/d=0.7. In longer distances the anomaly becomes indistinguishable.

As for the all types of geophysical anomalies, and for the IP anomalies in the case we are studying, the amplitude depends on the dimensions of the target as well. The anomaly is distinguishable and when the target has a ratio 1/h≈1/4. For the ratios 1/h≈1/10, the anomaly becomes negligible.

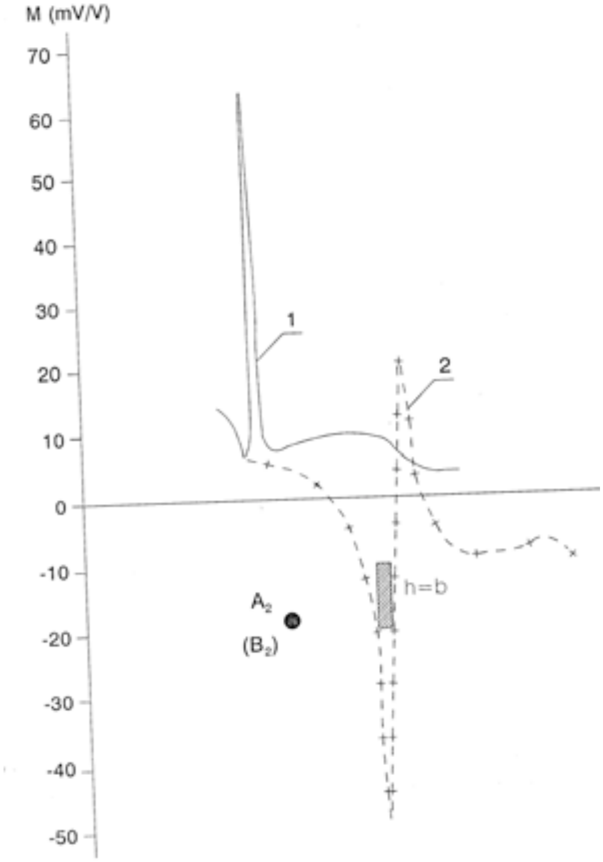
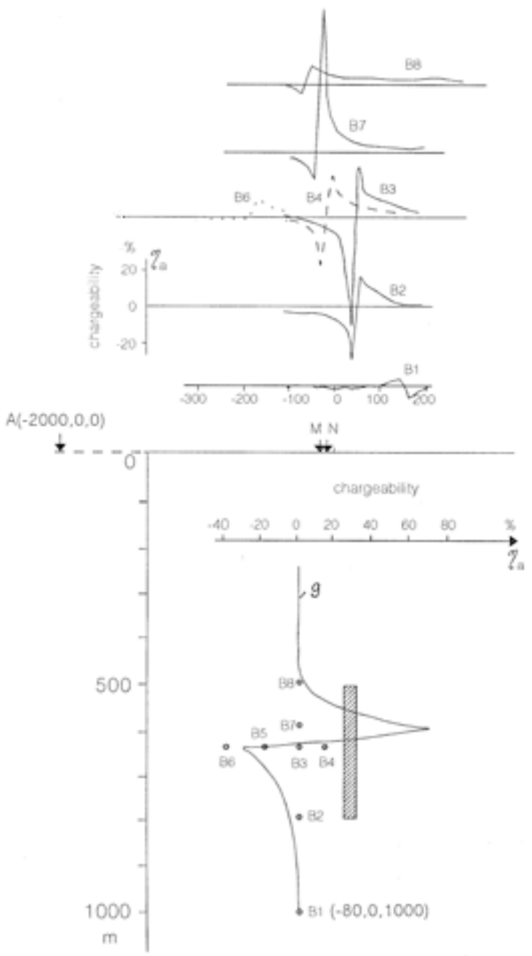


Fig 5. The IP surveyed anomaly in physical modelling over a polarizable prismatic target, with underground current electrodes. The IP plot surveyed with array: 1 - A B, 2 - A B .



6 - AB ; 7 - AB ; 8 - AB ; 9 - IP plot surveyed by moving the current electrode B in the borehole and measurement electrodes MN fixed on the surface.

On map, the IP anomaly is extended out of the target's extremities (Fig. 7), but in these sectors the anomaly configuration is different from that over the target: the positive part of anomaly is diminished and the amplitude of negative part becomes higher. In cases when the target is located out of the current dipole (AB) the anomaly presents the highest amplitude on target's edge. The anomaly is more intensive in the central survey line when the target occurs between the current electrodes. During interpretation, one should consider the extension of anomaly in dependence on the electrode array position in relation with the target. The target is located sidelong of the positive epicenter of anomaly but inside its negative part.

It is very important to discover rapidly in which side of the borehole is situated the ore body. To solve this problem two pairs of potential electrodes M_1, N_1 and M_2, N_2 are fixed on the surface and two sets of measurement for variable positions of the current electrode (A) in borehole are carried out. The anomaly recorded with potential dipole over the target is more intensive and without negative factors (Fig. 8). Through this methodology is determinate as well the depth of location of the current electrode in front of target and the position of the second current electrode on the surface for the future IP ground survey.

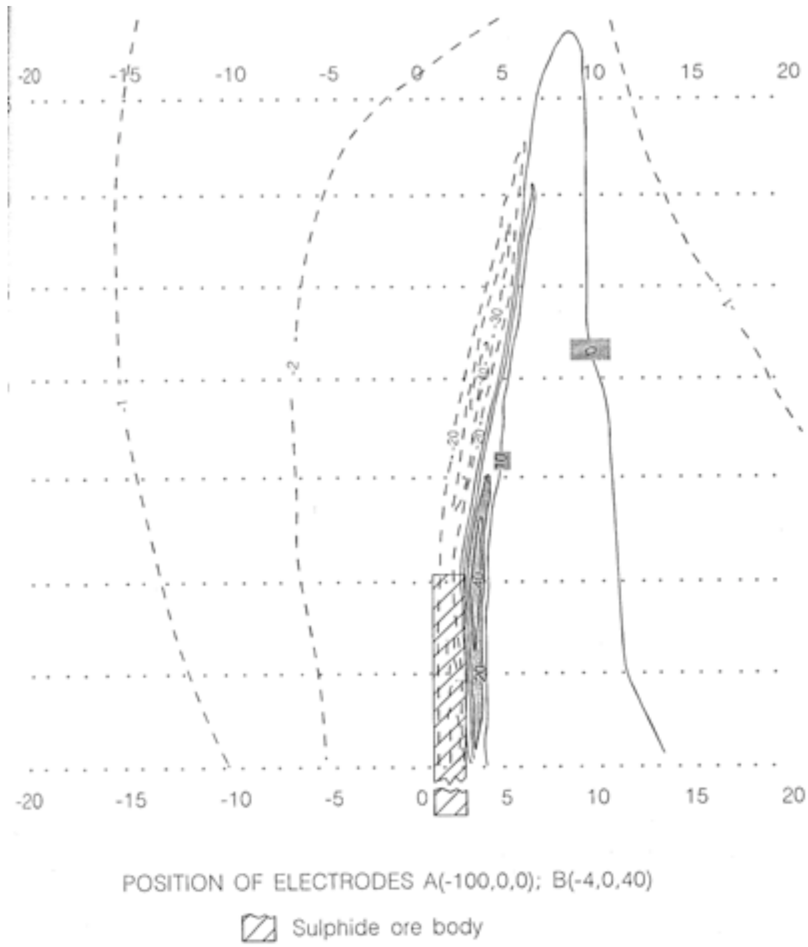


Fig 7. The modeling map of the IP anomaly according the measurements carried out with a current electrode placed underground. The position of electrodes is A(100,0), B(-4,0.4), 1 - Target.

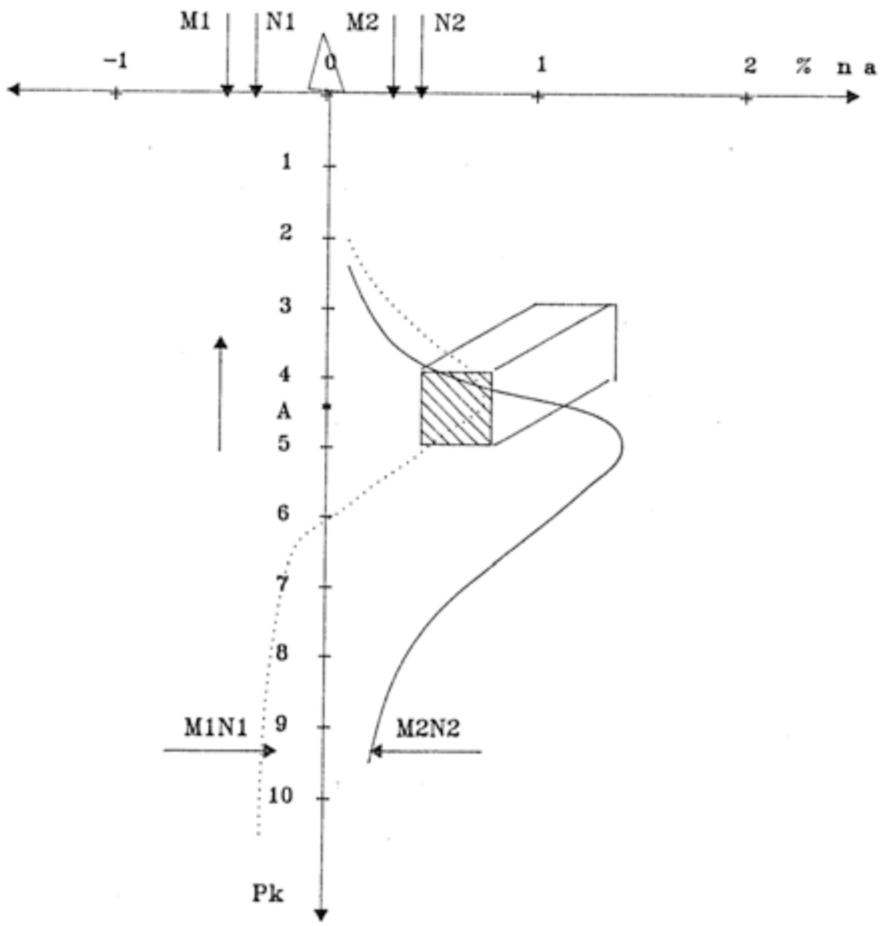


Fig 8. The configuration and amplitude of anomaly in dependence of the position of potential dipole in the Earth's surface.

5. Case histories

The controls of the mathematical and physical modeling results were carried out in our field experimental surveys (Avxhiu R. 1989, Frashëri A., Avxhiu R., Alikaj P. 1990).

In Fig.9 is presented a geological section where the drill hole has intersected the volcano-sedimentary series in which is located the sulphide mineralization (Alikaj P., 1989). IP anomal effect is negligible when the current electrodes are placed on the surface. It becomes intensive when the current electrode A is immersed on a borehole, at depth of 620 m. In this case, the anomal effect is caused by sulphide mineral zone intersected by borehole. This is also proved through the measurements carried out with fixed potential dipole (M,N) on the surface and moving current electrode in the ground. The mineralized zone is reflected in the IP anomaly from the depth 320 m and its highest amplitude reaches at depth 620 m, where the highest sulphide grade intersected by borehole occurs.

The case shown in fig.10 is more complicated. The surface measurements carried out with gradient array with spacing AB=3000 m, MN=100 m present an anomal sector (plot 1), beginning from the station 60, where the polarizable serpentinites outcrop, up to the proximity of the station 92, in

limestone rocks. A local anomaly is fixed between the stations 78- 92, over the volcano-sedimentary series. The measurements have been repeated with the current electrode A placed on the ground at the depth 212. At the station 82 a minimum of chargeability (M3) was obtained (plot 2). The maximum of M3 on the left should be related with the presence of serpentinites. The maximum on the right would be a supplied ore body at depth. To verify this interpretation some other boreholes were projected. In this Figure the profile of chargeability M3, recorded by the fixed potential dipole on the surface and by moving on the ground the current electrode, is shown too (plot 3). This profile presents an anomaly at depth 170-220 m.

We have also carried out borehole IP measurements with array MNA for spacing AM = MN = a = 2.5m, 5m, 10m, 20m, 40m (Langora L. et al. 1989). Based on mathematical models a depth investigation of such array was carried out. In fig.11 there are presented the results of such measurements over a geological section, where massive copper sulphide ore body, related with diabase rocks is located near the tectonic contact with serpentinized hatzburgites. The IP contours very clearly outline the ore body thought by fault tectonics.

Based on above-mentioned treatment one may draw into conclusion that IP surveys carried out with current electrodes placed on the ground is an effective way to increase the depth exploration of polarizable targets. Of course, these surveys need for powerful transmitters and high sensivity receivers. In our studies these requests were properly fulfilled by IPC-7/15 KW transmitter and IPR-10A or IPR-11 receivers, which we used both in borehole-surface measurements and in deep IP ground surveys with spacing up to AB=4000 m. This combination of the ways to increase the depth of investigation has shown good results (Avxhiu R.1989)

In fig.12 there is presented an electrical Real-section in one of copper sulphide deposits in Albania, together with IP contours carried out with gradient arrays of different spacings (Alikaj P.1989). Here the T=4 sec, t=2 sec and a current of 11 Amps were used. The surveys were done using three gradient arrays with lengths of 600m, 1200m and 2000m. As it is seen in fig.12, the short array was used to investigate in a depth of 75-100m and with IP chargeability M3=6-10mV/V the western edge of the upper mineralized level was fixed. When the array is increased up 2000m, the depth of investigation is up to 300-350m and the anomaly with chargeability over 16mV/V with epicenter in the point 108 was interpreted as connected with a deep mineralized zone. The borehole projected over that anomaly t this zone.

In the fig.13 there is given another electrical section with IP contours carried out with deep IP electrical soundings (Avxhiu R. 1989, Avxhiu R. et al. 1989). The deep soundings of IP carried out using arrays with a length up to AB=6000m have a depth of investigation up to 800-1000m. The anomalies with chargeability over 24mV/V were fixed over profiles Pr.2-Pr.4 at the depth. The borehole DH-6 over this anomaly met with the mineralized zone at depth of 520m.

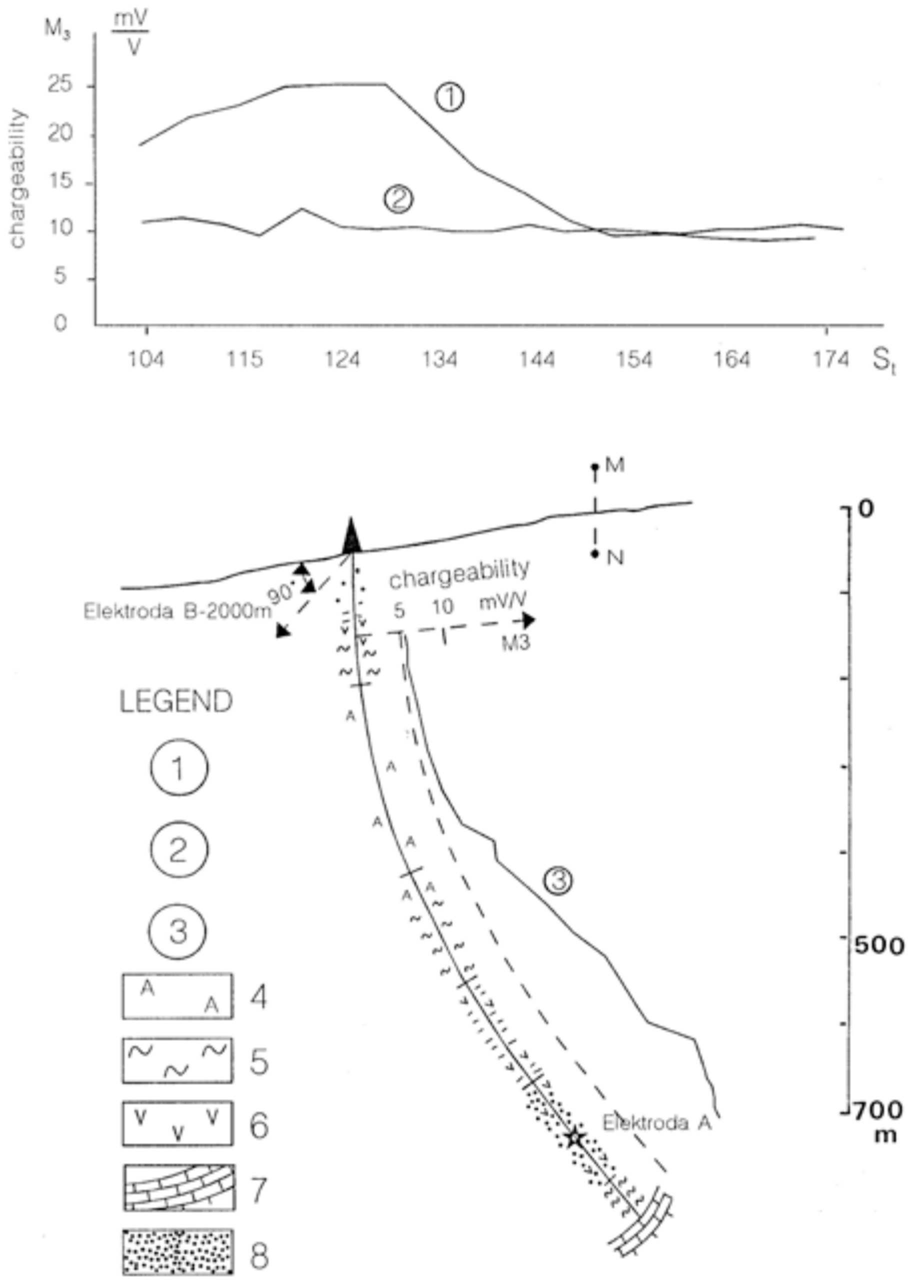


Fig 9. Increase of depth investigation of IP method setting the current electrodes into boreholes. The M3 IP plots surveyed: 1 - in the surface when the current electrode A was placed in the borehole; 2 - using the array AMNB on the surface; 3 - with fixed MN on the surface and with the current electrode A moving in the borehole. 4 -amphibolite; 5 - clay siliceous schist; 6 - diabase; 7 - limestone; 8 - sulphide mineral zone.

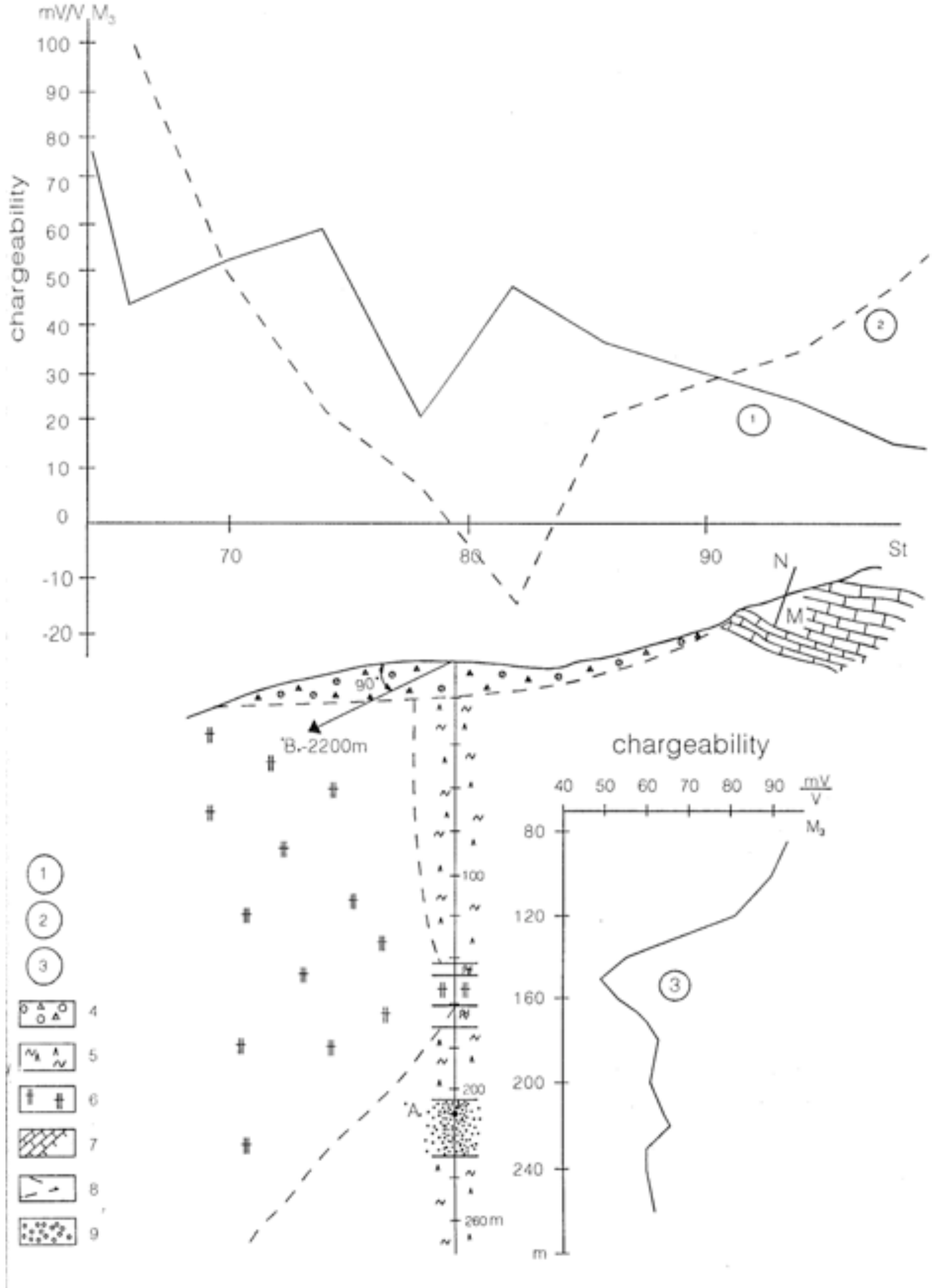


Fig 10. A geological section with surface and borehole -surface IP surveys. The M3 IP plot surveyed: 1 - with the array AMNB on the surface; 2 - on the surface when the current electrode A was placed in the borehole; 3 - with MN fixed on the surface and the currrent electrode A moving in the borehole. 4 - deluvions; 5 - volcanic sedimentary pack; 6 - serpentinites; 7 -limestones; 8 - disjunctive fault; 9 - sulphide mineral zone.

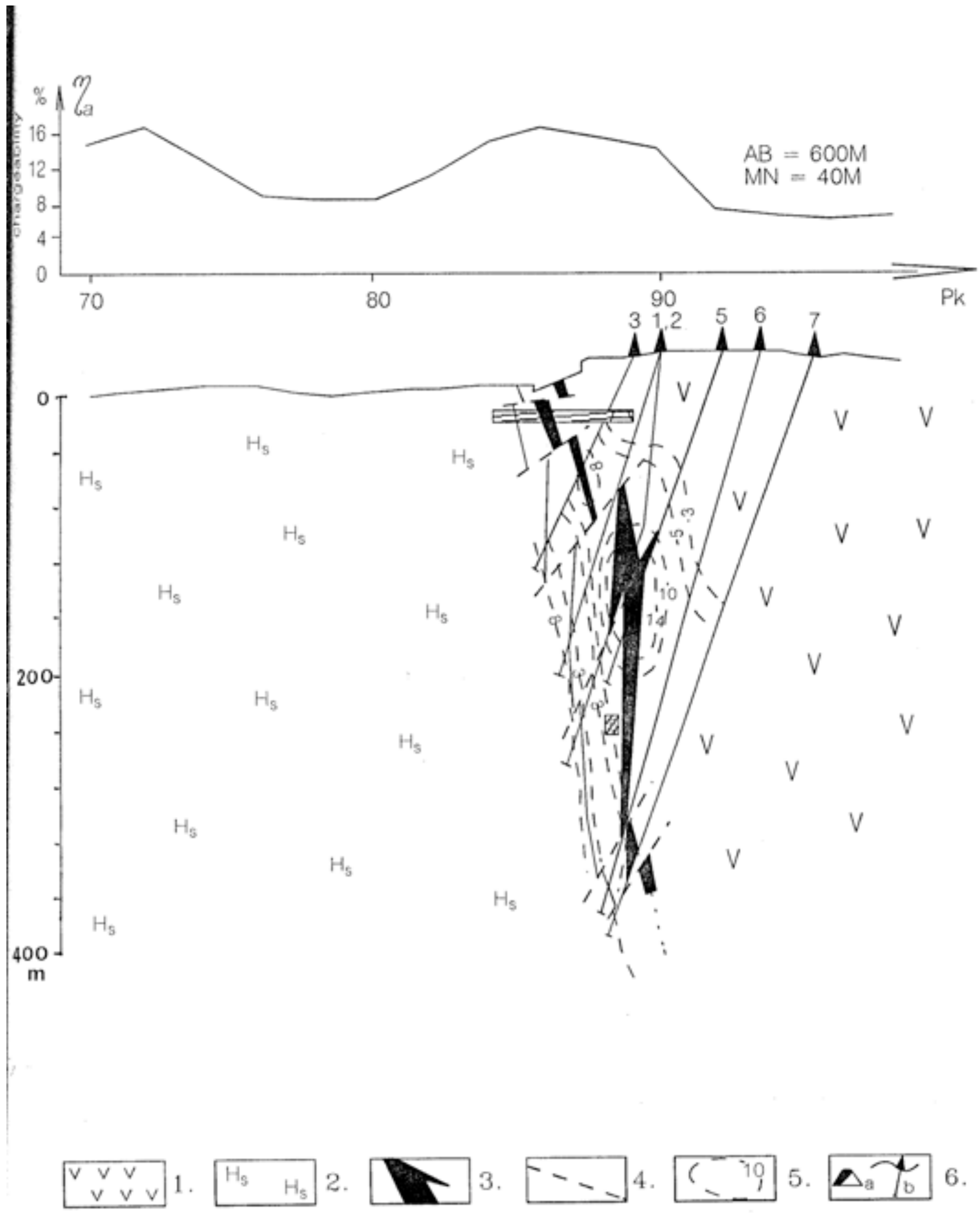


Fig 11. Geological section with IP contours according to the measurements carried out in boreholes with three electrode array. 1 - diabase; 2 - serpentinized hartzburgites; 3 - sulphide target; 4 - disjunctive fault; 5 - the M3 IP contours (in mV/V)surveyed using the array AMN,B-> (AM=MN=2.5m) moving in the borehole; 6 - mine works.

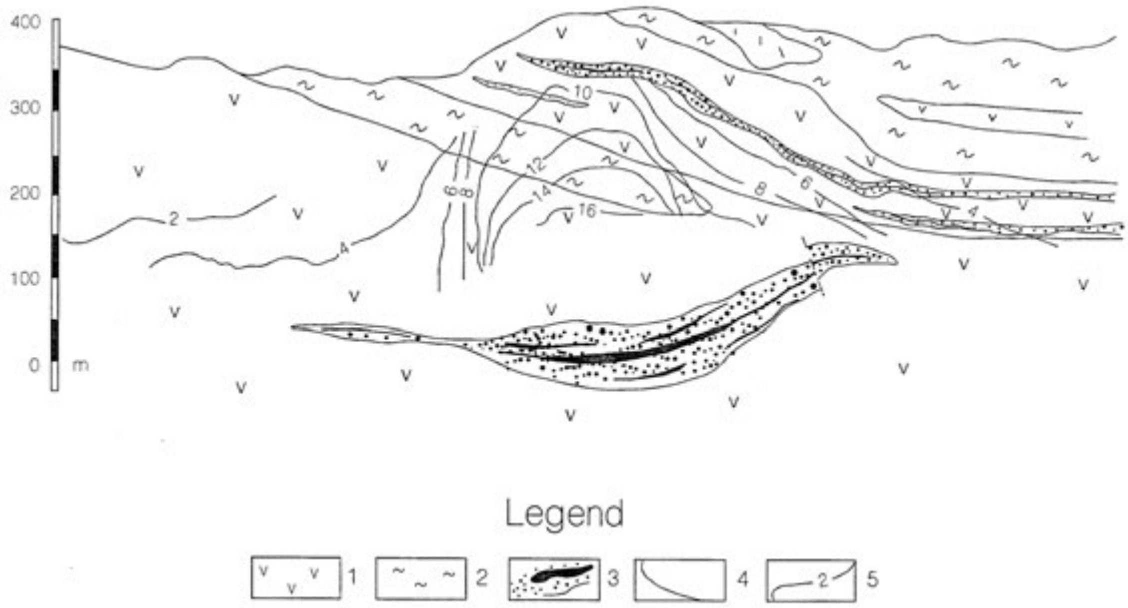


Fig 12. Increase of depth investigation using greater gradient array separations. 1 - volcanic rocks; 2 -detritic argilaceous pack; 3 - sulphide ore body; 4 -disjunctive fault; 5 - M3 IP contours in mV/V.

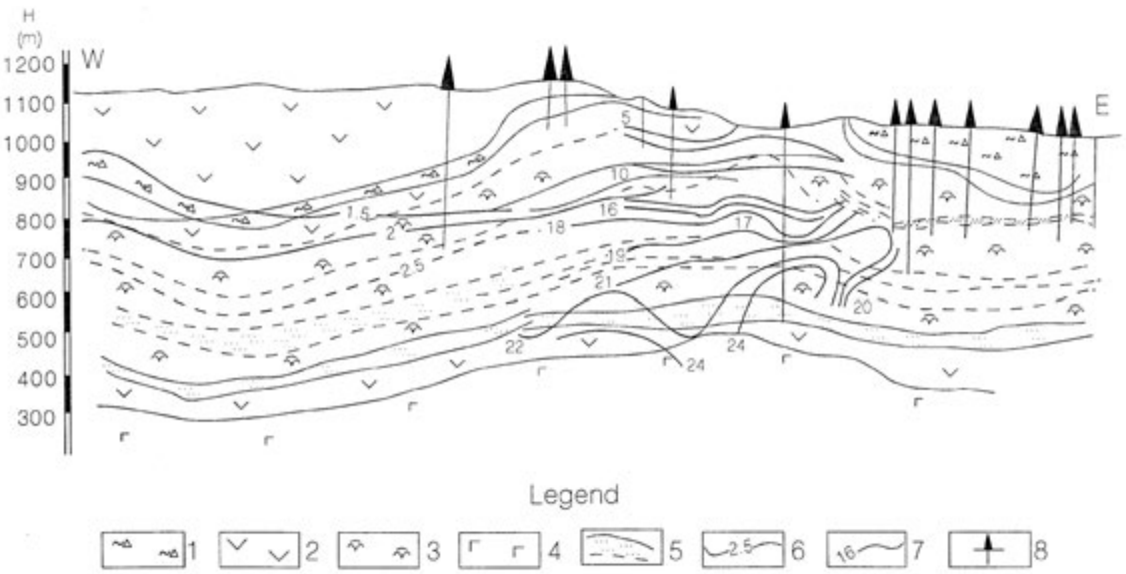


Fig 13. A longitudinal geological section with IP contours provided by deep IP electrical soundings. 1 - detritic argilaceous pack; 2 - volcano-algomeratic rocks; 3 - pillow lava; 4 - gabbro; 5 - sulphide mineral zone: a-verified, b-predicted; 6 - the IP contours in %; 7 - the M3 IP contours in mV/V; 8 - boreholes; 9 - lines of integration survey.

6. Conclusions

1. The IP anomal effect is strongly amplified if one of the current electrodes is placed in borehole, because the current flow density, passing through the ore body is increased.

2. The configuration of anomaly is determined by the position of the electrical array in relation with ore body and by its spatial position.

3. The IP anomaly, in plan contours, is longer extended than the target's edges. But, however, its character is different from the target projection.

4. The underground IP survey is one of the ways of increasing of depth exploration, at least up to depth 600-800m.

5. Our POLARELF-F (POLARELF-3), POLARPRIZ-2, POLARPRIZ-IP and POLARPRI-3P programs allow an accurate calculation of IP anomal effect of the polarizable targets of any shape with the same resistivity with surrounding rocks, for underground current electrodes.

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INTERPRETATION PROBLEMS OF ELECTRIC SOUNDING AND PROFILING IN REGIONS OF COMPLICATED GEOLOGY AND RUGGED TERRAIN

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Electric soundings in zones of complicated geology and rugged terrain (e.g. in the folded mountainous belt of the Albanids), have shown the existence of electric field scattering. The lateral changes of resistivity, the limited extension of geologic structures, the existence of several structures close to each other, and rugged terrain are characteristic features of this complicated geoelectrical medium.

Electric field scattering distorts the apparent resistivity values; if the apparent resistivity curves were interpreted without regard to the above phenomena and without performing correction for their effect, an unreliable view would be taken. Therefore the electric field scattering of the direct current was studied in a heterogeneous medium with curved boundaries and in rugged terrain. Potential response was computed with the aid of the quasi-harmonic equation (two- and three-dimensional) for boundary conditions of Neumann type. To solve the quasi-harmonic equation in a trapezoidal zone, in the lower half-space it was replaced by the corresponding variational problem, which can be solved by the finite-element method, giving an approximate representation of the electric field scattering. We have developed two computer programs in Fortran programming language for 2-D and 3-D modelling.

Results of some geoelectric models are given. In these models the electrical soundings are taken over the interface of different types of rocks and flexures, or above horsts and grabens. The programs are also used to correct different effects, including terrain effects.

Keywords: electric sounding, Albania, resistivity, finite-element analysis

1. Introduction

The widespread use of shallow electric soundings for engineering studies and in mineral prospecting and the use of deep electrical soundings in the search

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for oil and gas, have brought forth some problems related to the interpretation of the electric soundings in cases of complicated geology and rugged terrain in some regions of Albania. The experience gained and the theoretical analysis of the phenomena observed create possibilities for their solution and the overcoming of their influence.

Electric soundings are interpreted by comparing them with theoretical models of simplified geoelectrical sections (horizontal, sometimes inclined layers which are always flat and have infinite extent, without horizontal changes of the resistivity). In practice the use of electric sounding involves a number of aspects related to the surface geology and terrain:

— the relief is rugged in many areas;
— lateral (abrupt or gradual) changes of resistivity exist due to the presence of different types of rocks. The contact between them may be outcropped or may be covered by overburden;
— the geological structures have smaller extent than their depth, so the geoelectric boundaries are limited;
— various types of geological structures are often situated close to each other, at the same or different depths.

The above mentioned factors influence the scattering of the electric field and consequently the values of the apparent resistivity measured during the electric soundings.

2. Terrain effect in resistivity surveys

Rugged terrain causes deformations on the sounding and the resistivity profiles [DAHNOV 1953, KOEFOED 1979, FRASHËRI et al. 1984] due to the changes of the subsurface current distribution. For example when the current line configuration is perpendicular to the strike of a crest, the apparent resistivity at first begins to decrease, because of the decrease of the current density in the region where the potential electrodes are placed. The opposite is the case when the centre of the sounding is located over a valley. A more complicated influence appears on the resistivity curve when the centre of the sounding is located over the foot, or a crest, or over the side of a valley. If these deformations are not taken into consideration they may lead to a wrong interpretation. Evaluation of terrain effects can be made in two ways: firstly, taking into consideration not only the sounding to be interpreted but the neighbouring curves as well. At the same time information about the resistivity of the outcropped rocks in the sounding area must be provided. Secondly, correction of apparent resistivity with respect to the terrain effects is carried out.

For terrain correction we use the finite-element method to solve numerically the Laplace's equation in order to study the electric field behavior in a heterogeneous medium with curved boundaries of any configuration (*Fig. 1*). The finite-element modelling procedures are treated mathematically in several

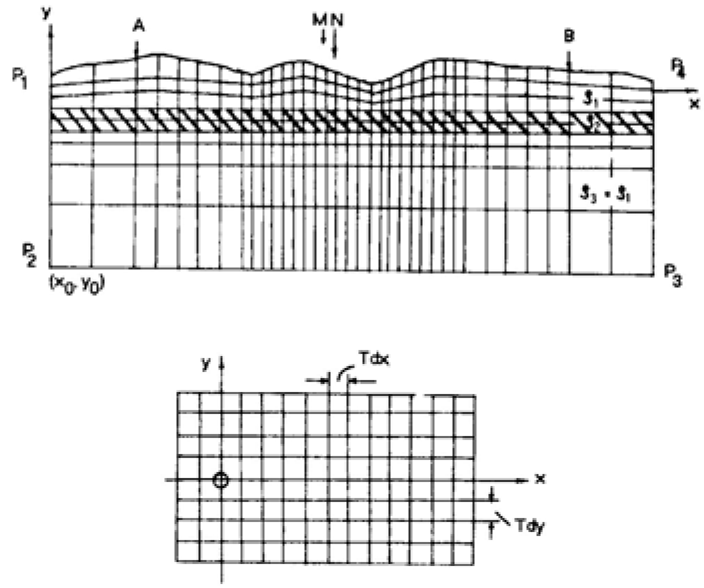

Fig. 1. Three-layer geoelectric model for finite-element method to compute two-dimensional terrain correction

1. ábra. Háromréteges geoelektromos modell kétdimenziós terrén korrekció számításához

Рис. 1. Двухмерная трехслойная геоэлектрическая модель для расчета поправки за влияние рельефа методом конечных элементов

publications [e.g. HOLCOMBE, JIRACEK 1984, FOX et al. 1980 or PRIDMORE et al. 1981]. For the calculation of terrain effect along two-dimensional structure a special algorithm was used, the mathematical elements of which are presented in earlier works of the author [FRASHËRI 1987, FRASHËRI et al. 1984].

In accordance with this algorithm a program, ELTRON-3, in Fortran-77 programming language was developed. This algorithm is different from those of many other authors [FOX et al. 1980, HOLCOMBE, JIRACEK 1984, MUNDRY 1984, SCRIBA 1981, PRIDMORE et al. 1981, GYIMESI, SIMON 1989]. We use the ordinary variational problem for elliptic differential equations as described by AMES [1977] and ZIENKIEWICZ [1977]. During the tests carried out on a BULL DPS7 computer with models consisting of a thousand nodes, the computer time ranged from 5 minutes (for profiling) to 30 minutes (for soundings). Correction of the terrain effects [FRASHËRI et al. 1984] and construction of synthetic curves of the apparent resistivity with arbitrarily curved layer boundaries for both sounding and profiling [FRASHËRI 1987] were performed by this program.

In *Fig.* 2 the correction of the terrain effects is presented when the relief is broken by a crest and a valley; the geological section has two half-layers divided by a vertical plane. Apparent resistivities, measured with fixed-source gradient and Schlumberger arrays, present minima over the crest and maxima in the valley, accompanied by smaller anomalies on both sides. After terrain correction, the profiles of the apparent resistivity assume their normal view.

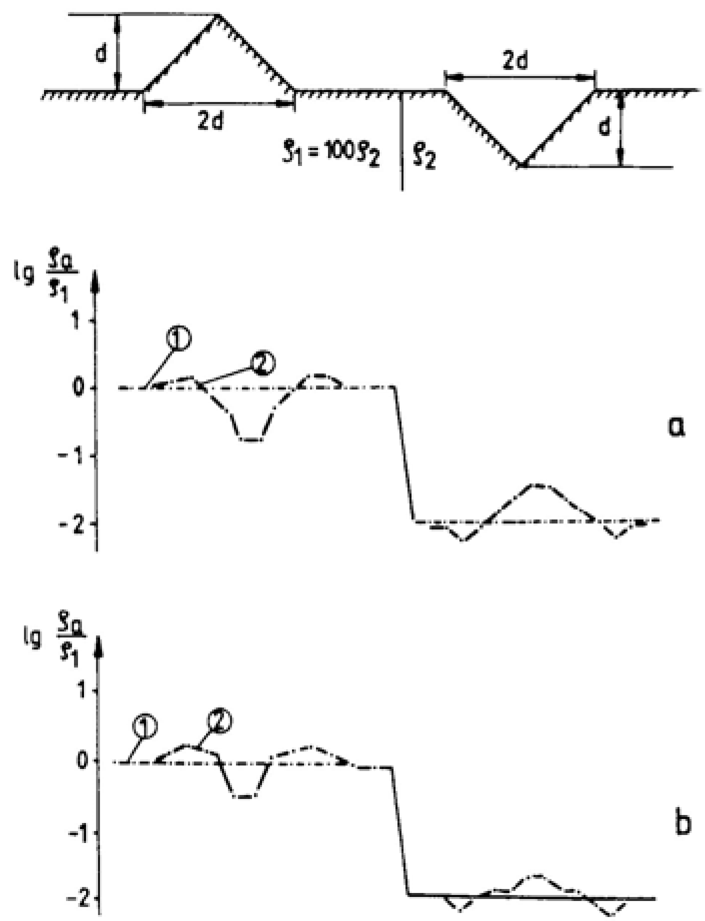

Fig. 2. Terrain corrections of resistivity profiling over a vertical contact, computed with ELTRON-3 program. a—fixed-source gradient array (MN=Δx=1/50 AB); b—on-line Schlumberger array (AB=6Δx=6 MN) 1—corrected curve; 2 —curve with terrain effects

2. ábra. Az ELTRON-3 programmal számított terrén korrekció értékek függőleges határfelület feletti ellenállás szelvényezéshez. a—gradiens elrendezés (MN=Δx=1/50 AB); b—Schlumberger elrendezés (AB=6Δx=6 MN) 1—korrigált görbe; 2— terrén hatást tartalmazó görbe

Рис. 2. Поправка данных электрического профилирования над вертикальным контактом, расчитанная программой ELTRON-3. а– по установке срединных градиентов при MN=Δx=1/50 AB; b–для симметричной установки AB=6Δx=6 MN 1–поправленный график; 2–исходный график с влиянием рельефа

In *Fig. 3* synthetic AMNB soundings carried out on a mountain crest and over a valley formed in homogeneous half-space are presented. For the soundings carried out over the valley or on the top of the crest, curves with similar appearance to the two-layer curves are obtained, the right flanks ascending and descending respectively. The interpretation of these curves may lead to a fictious two-layer section. When the soundings are carried out at the border of the crest or the valley, the curves have other three-layer configurations of the types K and H, respectively.

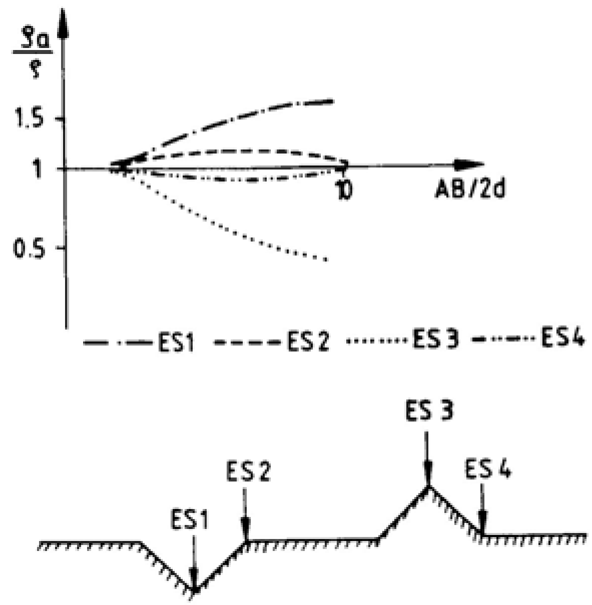

Fig. 3. Synthetic AMNB sounding curves over an isotropic homogeneous medium. Array parallel to the profile. ES1—in a valley; ES2—on the margin of a valley; ES3—at the top of a crest; ES4—on the margin of a crest

3. ábra. Szintetikus AMNB szondázási görbe izotróp homogén közeg felett. A terítés párhuzamos a szelvénnyel. ES1—egy völgyben; ES2—egy völgy szegélyén; ES3—egy hegygerinc tetején; ES4—egy gerinc szegélyén

Рис. 3. Теоретические кривые ВЭЗ над однородной изотропной средой. Точка ES1–размещена в долине; ES2–на крае долины; ES3–на хребте; ES4–на крае хребта

In *Fig. 4* apparent resistivity profiles of the fixed-source gradient array are presented over a section with 80 m level difference. Profile '1' is calculated in an analytical way with the above mentioned algorithm; profile '2' gained through physical modelling with electrical conductive paper is given for comparison. The shapes of these profiles are similar, although the absolute values of the apparent resistivity are different because the physical modelling does not possess the same conductivity as the mathematical model. The profiles reveal that the hills and the valleys cause anomalies of the apparent resistivity which amounts to some thousand ohmm above a medium of 1000 Ωm resistivity.

In all cases shown above, in the 2-D geoelectrical models the current sources A and B are point sources. All the soundings and the profilings are carried out parallel with the profile drawn in the figures.

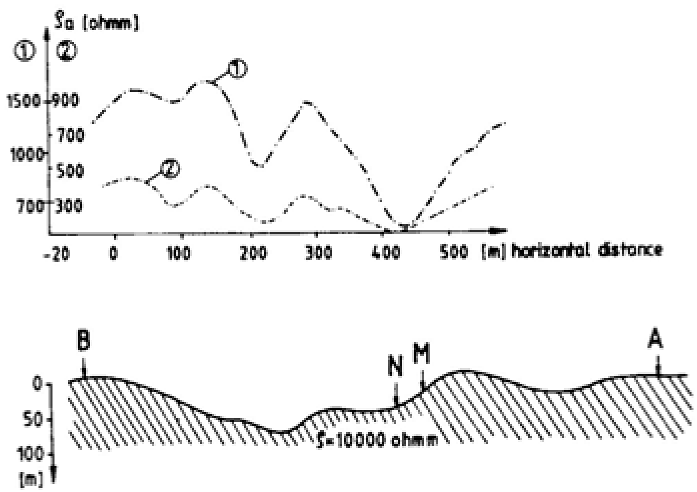

Fig. 4. Comparison of apparent resistivity profiles based on mathematical and physical modelling. Fixed source gradient array. 1—mathematical modelling; 2—physical modelling

4. ábra. Matematikai és fizikai modellezésen alapuló látszólagos ellenállás szelvényezés összehasonlítása. 1—matematikai modellezés; 2—fizikai modellezés

Рис. 4. Сопоставление графиков, полученных по данным математического и физического моделирования, для схемы срединных градиентов. 1—по данным математического моделирования; 2—по данным физического моделирования

3. Influence of buried and outcropped boundaries

Interfaces between rocks with different resistivity (for example limestones, flysch or halitic deposits in Albania) influence the scattering of the electric field: as a consequence the measured resistivity curve is deformed. The effect of outcropped, vertical contact was analysed by well-known authors [e.g. DAHNOV 1953]. Nomograms were constructed to correct the contact effect, when the position and the reflection coefficient of the contact are known. Evaluation of this influence is especially indispensable in the neighbourhood of resistive salt diapirs in Albania.

In *Fig. 5* a sounding observed near a salt diapir (1) is presented together with the corrected curve (2) for the influence of the vertical contact of the salts. The sounding is situated over flysch deposits with a resistivity of about 20 Ωm, covered by alluviums. The contact caused an increase in the resistivity of the second electric layer (flysch) to 50 Ωm and at the same time there are signs of a nonexistant third layer of high resistivity. After correction, these false phenomena could be avoided.

The study of the influence of more complicated boundary was possible by the ELTRON-3 program for 2-D models and ELTRONHA for 3-D models [FRASHËRI 1987]. In *Fig. 6* electric soundings are presented over two-layer models with a buried vertical contact. Interpreting the curves deformed by the

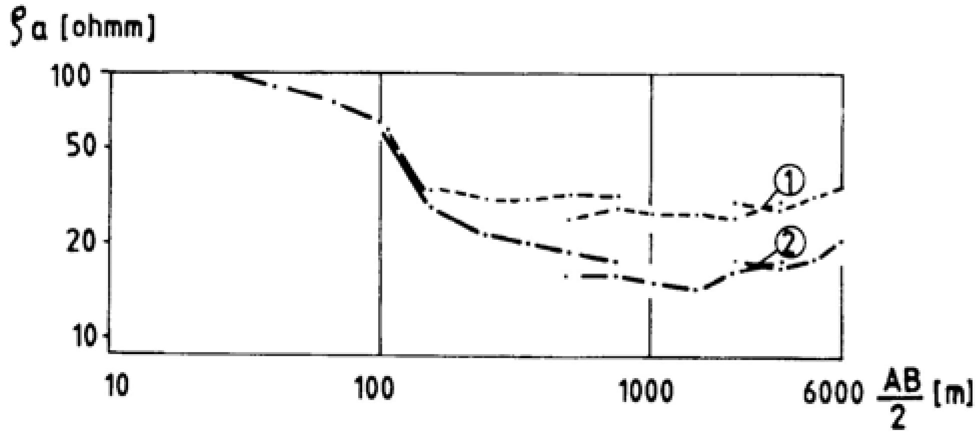

Fig. 5. Deformation of the apparent resistivity curve from the vertical contact and correction 1—uncorrected; 2—corrected

5. ábra. Látszólagos ellenállás görbe függőleges határfelület által okozott torzulása, és korrekció 1—nem korrigált görbe; 2—korrigált görbe

Рис. 5. Наблюденные искаженные и поправленные кривые при наличии вертикального контакта 1—наблюденная кривая; 2—поправленная кривая

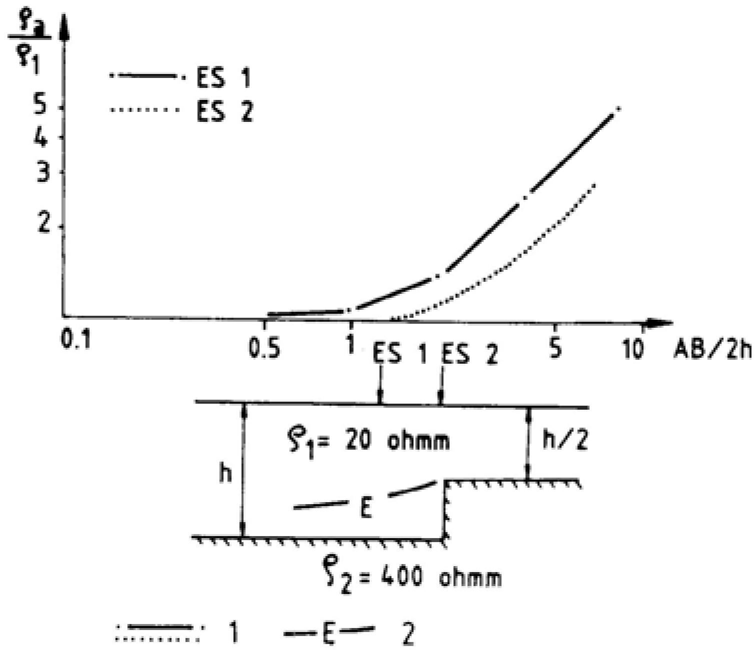

Fig. 6. Effect of a buried vertical contact. 1—sounding curves modelled with ELTRONHA program; 2—interpreted (false) boundary without the influence of vertical contact

6. ábra. Eltemetett függőleges határfelület hatása. 1—az ELTRONHA programmal modellezett szondázási görbe; 2—értelmezett (hamis) határfelület a függőleges érintkezés hatása nélkül

Рис. 6. Влияние флексуры. 1—кривая ВЭЗ, расчитанная по программе ELTRONHA; 2— ложный геоэлектрический горизонт, полученный при интерпретации непоправленной кривой

influence of the contact, the top of the basement is defined as being at a shallower depth than it really is. The impression of the existence of a right-hand structural flank is also created.

From the results of this modelling it can be concluded that precise determination of the thickness of the first layer can be carried out only when this thickness (i.e. the basement depth) is at least ten times smaller than the sounding distance from the vertical contact. For smaller distances the effect is not negliglible and the curves need to be corrected. In order to do this, we should previously know the position of the near-vertical contact. The presence of the vertical (even buried) contact of high resistivity causes a more distinct increase of the apparent resistivity in the right flank of the curve than in the case of horizontal layers. This peculiarity creates the possibility of detecting (in some cases) the vertical contact of high resistivity.

4. Influence of lateral resistivity changes in the geoelectrical horizons

Geophysical prospecting has revealed that there are facial changes, which in some regions of Albania are accompanied by great lateral resistivity changes. For example, the calcareous core of an anticline with limited (as small as 1-2 km) dimensions and the terrigenous deposits around it represents an extraordinarily great lateral change in the layer resistivity.

In order to study the influence of the lateral change of the layer resistivity for this type of anticline, we modelled — exploiting the ELTRON-3 program — the case when the structure is slightly wider than its depth (see *Fig. 7*). Analysing the calculated curves, it is obvious that the side effects of the resistive basement is felt even at long distances from the edge of the horst, and it is expressed by an increase in the apparent resistivity.

Two-layer curves of the apparent resistivity do not have regular configuration, they are much more similiar to the curves of inclined layers with considerable dip angle to the side vertical contact. If the electric soundings are carried out with a shorter array than is needed for the whole curve, only the beginning of the upward left flank will be obtained. Observing these short curves it can be supposed that the top of the limestone becomes deeper the further it is from the horst centre, belonging to a wide anticlinal structure. Over structures that have comparable dimensions and layering depth, the apparent resistivity is reduced as a consequence of current deviation because the electric current flows alongside the structure. This causes the top of the structure to appear as if it is at a greater depth than it really is.

Sounding carried out in grabens filled with conductive overburden and bordered by rocks of high resistivity (e.g. limestone), displays a deformed curve as well, when the width of the graben is smaller then the length of the electrical sounding array. To avoid the influence of the above analysed phenomenon and the misleading interpretation the following measures should be taken:

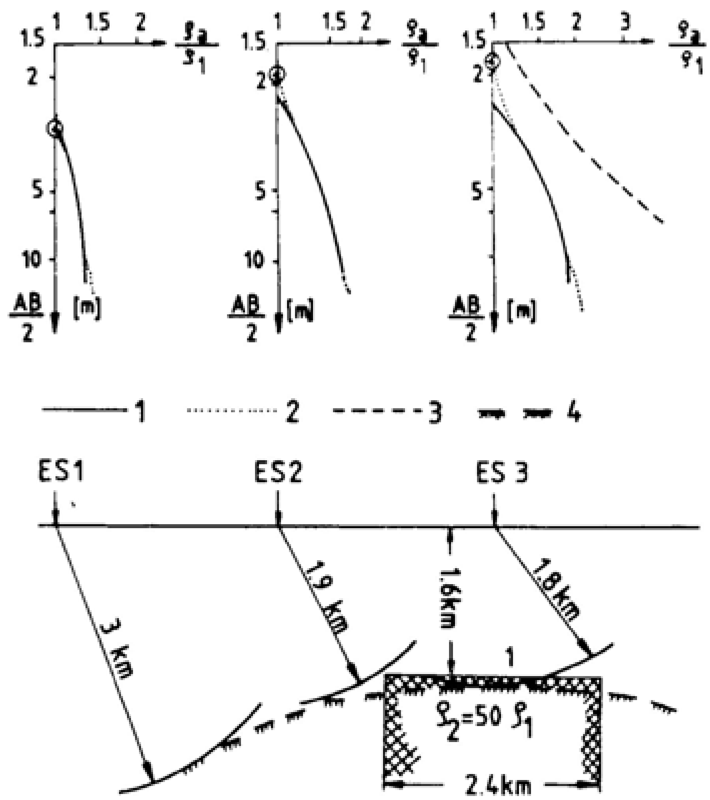

Fig. 7. Apparent resistivity curves placed across a horst. 1—synthetic curves computed with ELTRON-3 program; 2—analytical curves that fit to the synthetic curves; 3—analytical curve assuming the horst to be horizontally infinite; 4—geoelectric horizon after interpretation which does not consider the horst limited in the horizontal direction

7. ábra. Látszólagos ellenállás görbék egy sasbércen keresztül. 1—az ELTRON-3 programmal számított szintetikus görbék; 2—a szintetikus görbére illesztendő analitikus görbék; 3—analitikus görbék a sasbérc oldalirányú végtelen kiterjedését feltételezve; 4— geoelektromos szint értelmezés után, nem véve figyelembe a sasbérc korlátozott oldalirányú kiterjedését

Рис. 7. Кривые ВЭЗ по профилю, расположенному вкрест горста.1—Синтетические кривые, расчитанные по программе ELTRON-3; 2—Теоретические кривые, совпадающие с синтетическими; 3—теоретические кривые при горизонтальном положении кровли бесконечного горста; 4—Ложный геоэлектрический горизонт, полученный при интерпретации без учета влияния ограниченности горста в боковом направлении

— field and regular surveys should be carried out, to detect as clearly and surely as possible the structures. When interpreting the soundings, structures may turn out to be different in form and dimensions from the surrounding structures and may not correspond to the recognized tectonics of the region. In such cases the side effects of the soundings should be thoroughly studied;

— study of the structural form should be carried out together with a study of the lateral resistivity changes in the layers constituting the section over the geoelectric horizon as well as the horizon itself;
— sounding should be carried out with long array, so that the sounding curve to be as complete as possible; this allows us to carry out some sort of classification of the distortion effects;
— interpretation of the curves carried out in the regions of complicated geology should not be carried out solely by comparing the theoretical models for horizontal layers. Interpretation should begin with a comparison of the curve of the parametric soundings on boreholes with the synthetic curves calculated from the data of electrical well logging. These synthetic curves should be computed for simple models with horizontal layers as well as for the supposed geoelectrical structures in the region applying the ELTRON-3 program.

5. Conclusions

The apparent resistivity values measured during electric soundings in geologically disturbed (tectonized, folded, mountainous) zones reveal the influence of lateral contacts, gradual lateral changes of resistivity, and of the rugged terrain. The influences can add up to 50% of the resistivity values. Hence the curves of the electrical sounding are deformed, thereby influencing the geoelectrical interpretation as well. To analyse the above mentioned effects it is necessary to implement a regular grid of soundings and it is advisable to keep the length of the arrays sufficiently long. Correction of the apparent resistivity values is needed. The finite-element method is suitable for computing the apparent resistivity of soundings or profilings in a heterogeneous environment. The programs ELTRON-3 for 2-D models and ELTRONHA for 3-D models can be utilized for this purpose. These models are of great value for qualitative interpretation.

To avoid the terrain effects, the effects of the buried vertical contact, and the lateral structures parallel to the array, it is essential to use 3-D finite-element modelling.

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ELEKTROMOS SZONDÁZÁS ÉS SZELVÉNYEZÉS ÉRTELMEZÉSI PROBLÉMÁI BONYOLULT FÖLDTANI SZERKEZTŰ ÉS EGYENETLEN FELSZÍNŰ TERÜLETEKEN

Alfred FRASHËRI

Komplikált geológiájú és egyenetlen felszínű területeken (pl. Albanidák gyűrt hegyláncai) végzett elektromos szondázások az elektromos tér szóródását mutatták. A bonyolult geoelektromos közeg jellemzői az ellenállás oldalirányú változásai, a geológiai szerkezetek véges kiterjedése, számos, egymáshoz közel fekvő szerkezet és az egyenetlen felszín.

Mivel az elektromostér szóródása torzítja a látszólagos ellenállás értékeket, az ellenállás görbék kiértékelése e jelenség figyelembevétele és hatásainak korrigálása nélkül megbízhatatlan kép kialakulásához vezethet. Ezért egyenáram elektromos terének szóródását vizsgáltuk heterogén közegben, törött határfelületek és egyenetlen terepviszonyok mellett. A potenciál válaszokat kváziharmonikus potenciálegyenlet (két- és háromdimenziós) segítségével határoztuk meg, Neumann-féle határfeltételek figyelembevételével. A kváziharmonikus egyenlet trapezoid alakzatra való megoldásához az alsó féltérben a megfelelő variációs problémával helyettesítettük azt. Így a véges elemes módszerrel előállítható a megoldás, az elektromos tér szóródásának egy közelítő leírását biztosítva. Két számítógépes programot készítettünk Fortran nyelven, kétdimenziós és háromdimenziós modellezéshez.

Bemutatjuk néhány geoelektromos modell eredményét. A modellekben az elektromos szondázásokat különböző típusú kőzetek határfelületei, vagy sasbércek és árkok fölé helyeztük. A programok különböző hatások korrekcióinak végrehajtására is szolgálnak, beleértve a terrén korrekciót is.

Geophysical Prospecting, 1995, 43, 743–757

On the application of geophysics in the exploration for copper and chrome ores in Albania[1]

Alfred Frasheri,[2] Ligor Lubonja[3] and Perparim Alikaj[2]

Abstract

Some generalized results of geophysical exploration for copper sulphide and chromite ores in Albania are presented. The most important geophysical methods used are electrical prospecting, gravity, magnetics and electromagnetics. Physical properties of the ores, genesis and geological problems to be solved have determined the proper choice of any of these methods in the complex exploration.

Introduction

The search for copper and chrome ores in Albania, as well as for other solid minerals, oil and gas included is carried out using a wide complex of geophysical and geochemical methods.

In mineral exploration geophysical methods have contributed to the search for ore bodies or mineralized zones and in geological mapping.

Electrical prospecting and sometimes magnetics, EM and gravity have been the main methods used in the search for copper sulphide deposits. Exploration to a depth of 600–700 m has been performed with the induced polarization (IP) method.

Chromite ore exploration has been carried out using gravity, magnetics and induced polarization methods. Many good results have been obtained but in comparison with copper exploration, chromite exploration is more complicated and more problematic.

Physical and geological bases for geophysical exploration of copper and chrome deposits

Copper ore deposits in Albania are mainly connected with an ophiolitic belt in the Mirdita zone. Mineralization is present in the form of sulphides such as pyrite and chalcopyrite located in volcanogenic rocks (diabase, spilite, keratophyre) and in

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Table 1. Physical properties of copper sulphide ores and surrounding rocks.

Sample	Chargeability,* in mV/V			Resistivity, in ohm * m			Density, in kg/m^3			Magnetic susceptibility in $\times 10^{-5}$ SI Unit		
	Min	Max	Mode	Min	Max	Mode	Min	Max	Mode	Min	Max	Mode
1 Pyrite-chalcopyrite ore of different sulphide content and textures	18	900	250	0.1	1200	30	2600	4100	3200	10	5000	20† 1000‡
2 Quartz-pyrite-chalcopyrite	5	354	130	15	1650	—	2610	3680	3100	30	2000	50† 1000‡
3 Diabase	4	15	6	320	7000	1200	2700	3200	2800	15	160	75
4 Altered diabase	3	18	7	20	300	200	—	—	—	—	—	—
5 Gabbro	6	16	8	280	5800	450	2700	3200	2800	30	320	150
6 Quartz diorite	5	12	8	150	3000	600	2360	2750	2670	70	1800	220
7 Schistose detritus overburden with clays and silica	3	10	5	4	180	20	2200	2500	2400	10	200	40

* Chargeability amplitude, calculated as spectral IP parameter (m).
† Ores without pyrrhotite.
‡ Ores with pyrrhotite.

effusive rocks of volcano-sedimentary formations, and in the form of quartz-sulphides in gabbro rocks. The mineralization in volcanogenic media forms either concentrated orebodies or simply disseminated sulphide zones or both. The mineralized zones range from some metres to some hundreds of metres wide and from some tenths of metres to kilometres on strike. Massive or veinlet orebodies are often present inside these mineralized zones. In volcano-sedimentary formations, mainly massive orebodies are found.

In Table 1 the results of a petrophysical study of copper sulphide ores and the surrounding rocks are given (Avxhiu 1979; Alikaj 1989). Several hundreds of examples have been tested for every physical parameter included in the study.

The most typical and distinctive physical properties are chargeability and resistivity which are conditioned by mineral content, structure and degree of rock alteration. The surrounding rocks are characterized by a low value of chargeability and a higher resistivity than sulphide ores.

The sulphide ores have a higher density than the surrounding rocks and when they contain pyrrhotite and/or magnetite they exhibit magnetic properties.

These four properties serve as bases for the application of IP, resistivity, EM, self-potential and mise-à-la-masse in copper deposit exploration. Occasionally, magnetic and gravity methods have also been used.

The chrome ore deposits are linked mainly to the upper part of a harzburgite-dunite-tectonite sequence, as well as to the lower part of a dunite cumulate sequence of ultramafic massifs. Most chrome-bearing deposits are of podiform type, less are stratiform.

Dunites and harzburgites are often serpentinized and contain secondary magnetite in a fine-grained disseminated form or thin veinlet.

These orebodies occur as sparsely-to-densely disseminated, nodular, belted or massive chromites. The type of ore is chromespinelid, mainly magnesian and sometimes ferrous. Its chemical composition is simple and the content of olivine and serpentine varies. In some cases the chromite grains are enclosed by secondary magnetite membranes, which are crystallized as a result of intense dynamic processes. Secondary magnetite is also present in chromite and serpentine.

In Table 2 the physical properties of various kinds of chrome ores and ultramafic rocks are presented (Frasheri 1974; Lubonja and Frasheri 1966).

The chrome ore density is determined by the Cr_2O_3 content and, in general, for a simple case, the following dependence is observed (Frasheri 1968):

$$\delta = 40X + 2000,$$

where δ is the ore density in kg/m^3 and X is the percentage of Cr_2O_3 in the ore.

This relationship is not unique, because the ore density is dependent on the degree of serpentinization of the olivine and also on the microfissures.

Large chargeability values are characteristic of chromites which contain secondary magnetite in veinlet or network form. Due to chemical and thermal remanant magnetization, some chromite ores are magnetic.

Table 2. Physical properties of chrome ores and ultramafic rocks.

		Density, in kg/m³			Magnetic properties in × 10⁻⁵ SI Units: Susceptibility			Magnetic properties in × 10⁻⁵ SI Units: Remanant magnetization			Chargeability in mV/V			Resistivity in ohm-m	
No	Sample	Min	Max	Mode	Min	Max	Mode	Min	Max	Mode	Min	Max	Mode	Min	Max
1	Chrome	2450	4380	3700	10	500 3000*	150 300	70	8100	2800	5.5	720	78	700	3600
2	Dunite	2700	3340	3020	10	1000	250	10	900	150	3	60	8	2200	7000
3	Serpentinized dunite	2600	2800	2700	40	3000	250	10	800	700	5	643	12 94 517	100	650
4	Harzburgite	2800	3300	3050	10	700	200	10	1300	100 500	3	15	6	2400	7100
5	Serpentized Harzburgite	2700	2900	2800	20	1000	400	10	100	250	4	814	22 76 591	120	680
6	Serpentinite	2240	2650	2550	10	8000	1100	10	70000	300	3	950	15 92 605	35	100
7	Pyroxenite	2900	3200	3080	10	320	100	10	71000	150	2	6	4	170	1800

* Ores with high content of secondary magnetite.

The petrophysical properties of ultramafic rocks are mainly subject to the degree of serpentinization and the physical and mechanical conditions. From Table 2, the following conclusions can be drawn:

1. Density is the most stable and typical property used to differentiate between chromite ores and ultramafic rocks, thus gravity is the basic method used in our chrome exploration.
2. The values of geophysical anomalies over orebodies depend on the physical contrast between the chromite and the surrounding rocks.
3. Sometimes the physical property contrast between chromite and ultramafic rocks is very low, and thus no geophysical anomaly of this parameter can be observed.
4. Over some areas of ultramafic rocks, some geophysical anomalies can be fixed, due to a physical property contrast with the surrounding rocks.

Based on these conclusions we can state that geophysical anomalies reveal some targets which have a high probability of indicating the presence of chrome orebodies. Their lack shows only that within the depth of investigation, orebodies exhibiting a sufficient contrast to ultramafic rocks do not exist. Thus, geophysical exploration for chrome ore is rather complicated, and an integrated interpretation of geological, geophysical and geochemical methods should be used.

Geophysical exploration for copper ore deposits

During the 1960s the main electrical prospecting method used in copper exploration in Albania was the self-potential (SP) method. Resistivity and magnetic surveys were also carried out, and occasionally the gravity method was used. Good results were obtained from this integrated interpretation for shallow depths, some tenths of metres (Fig. 1) (Frasheri 1963).

After rapid development in the early 1970s, the IP method became the major surveying method for copper sulphide exploration, while the other methods served as complementary or follow-up methods. In this period the depth of investigation increased to 200 m (Fig. 2) (Avxhiu 1979).

In the last decade our copper exploration was extended to greater depths, to 400–700 m. For this purpose we used the following procedures:

1. New IP instrumentation consisting of a high-power transmittter and a high-sensitivity receiver was used (IPC-7/15KW, IPR-10A, IPR-11), produced by SCINTREX.
2. The surface-to-hole IP responses were studied theoretically and experimentally to investigate the orebodies around the boreholes, especially at great depths (Lubonja *et al.* 1985).
3. The possibility of separating low amplitude and frequency IP anomalies was also studied (Lubonja *et al.* 1984).

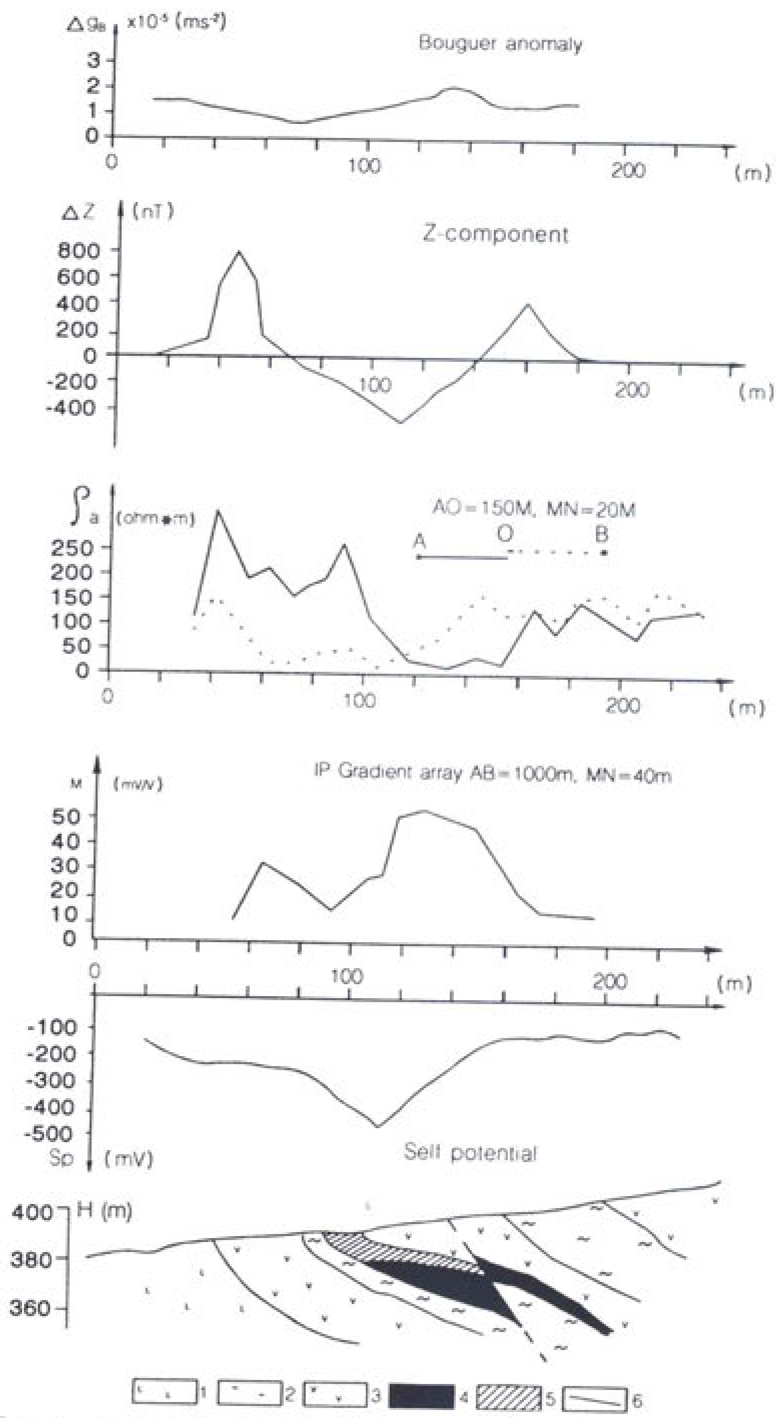

Figure 1. Geophysical profiles and geological section of a copper sulphide ore deposit. (1) Ultrabasic rock. (2) Argillaceous schists. (3) Diabase. (4) Massive orebody. (5) Disseminated mineral zone. (6) Tectonic faults.

4. The results from direct mineral exploration and geological mapping by geophysical methods were coordinated (Avxhiu, Bushati and Alikaj 1984).

In theoretical studies, the IP field distribution in heterogeneous geological media, with a lithological boundary of any shape, over a rugged relief was investi-

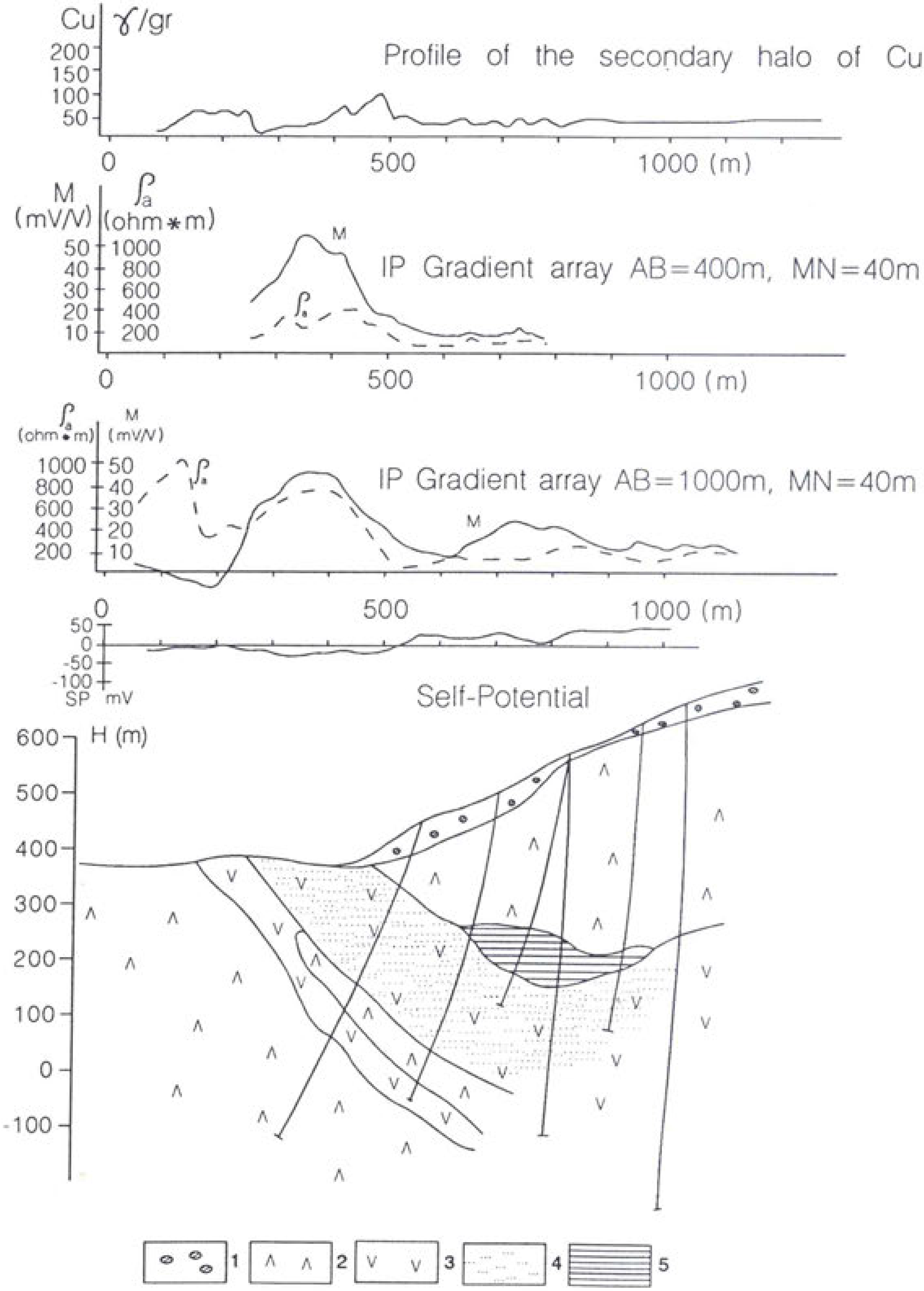

Figure 2. Geophysical and geochemical profiles over the cross-section of a copper sulphide ore deposit. (1) Overburden. (2) Keratophyre rocks. (3) Spilites. (4) Disseminated sulphides. (5) Massive sulphide orebody.

gated. Applying the finite-element method and other techniques, the proper algorithm and software were developed for computation of synthetic IP anomalies (Frasheri, Tole and Frasheri 1984; Frasheri 1987; Frasheri 1989). Mathematical models were computed for polarizable bodies of any geometrical shape, with or without resistivity contrast, in 3D, 2.5D and 2D. The current electrode could be set on the surface or underground.

As a result of theoretical and experimental studies in different geological media, the depth of investigation using the IP method in copper sulphide exploration has increased markedly, to 600–700 m. Figure 3 shows such a case in a volcano-sedimentary formation in north-east Albania. The survey was carried out using deep IP soundings with a maximum separation of current electrodes of AB = 4400 m.

Chargeability responses for every separation are plotted at points located at the approximate depth of investigation, Hi. The geological data are plotted on the same

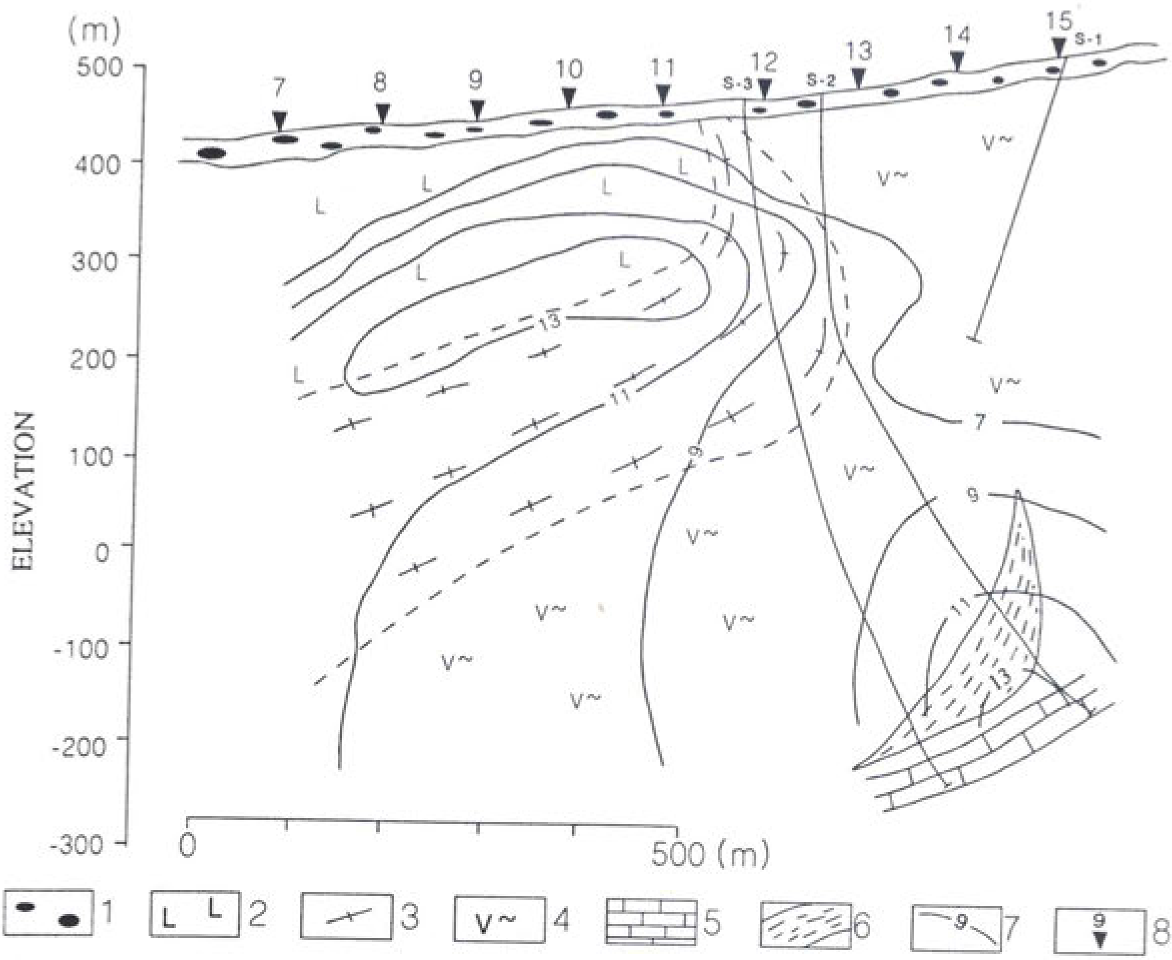

Figure 3. Real section of chargeability (M4) according to the VES-IP measurements in volcano-sedimentary formations. (1) Overburden. (2) Ultrabasic rocks. (3) Amphibolites. (4) Volcano-sedimentary rocks. (5) Limestones. (6) Disseminated and veinlet sulphides. (7) Chargeability contours in mV/V. (8) Centre and the number of VES-IP.

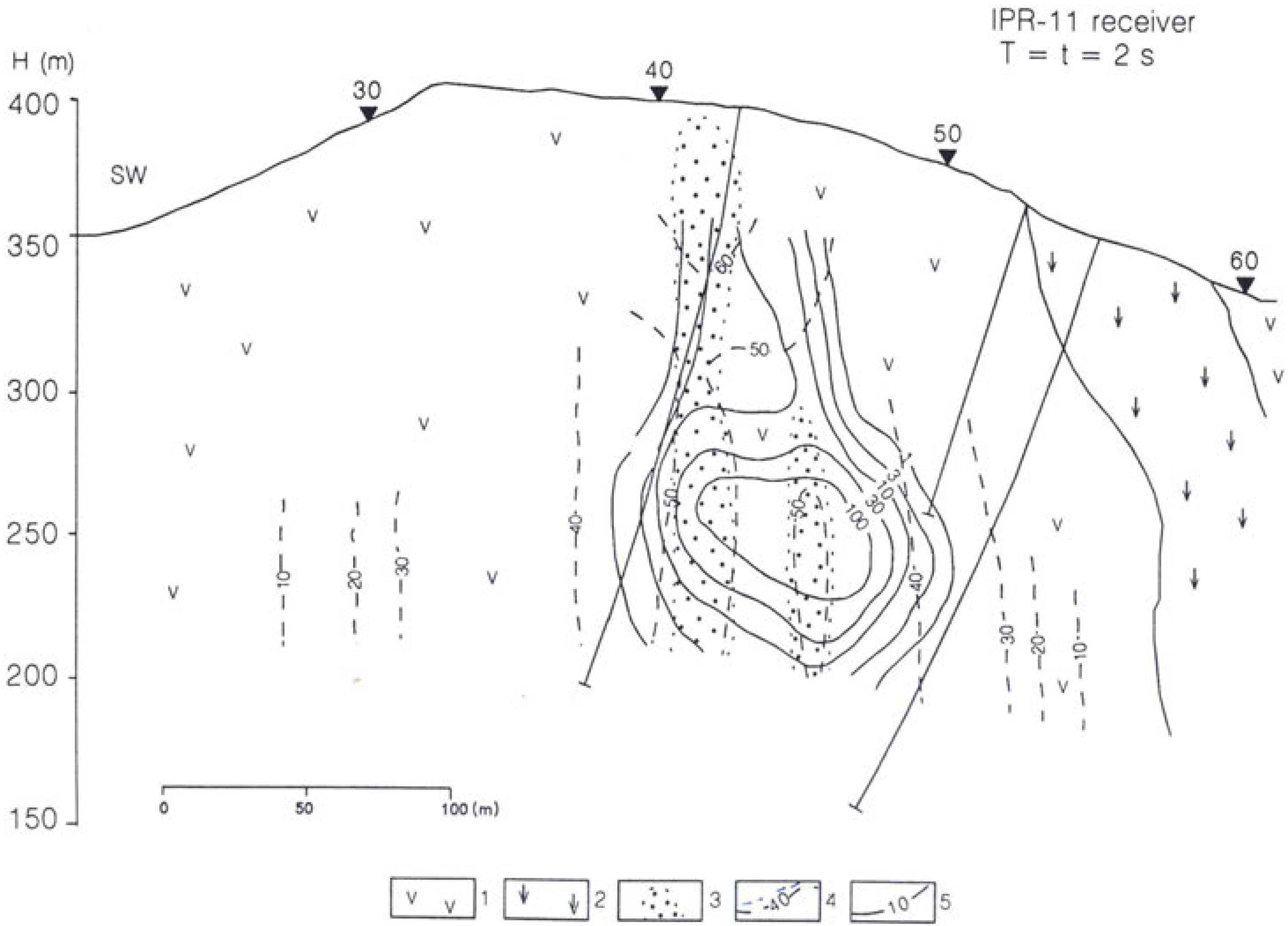

Figure 4. 'Real section' of the chargeability (M4) and apparent time constant spectral IP parameter (τ) over a mineralized sulphide zone. (1) Diabase. (2) Harzburgite. (3) Mineral zone. (4) Chargeability in mV/V. (5) Spectral time constant τ in sec.

section. This type of presentation is called a 'real section' (Alikaj 1989; Langore *et al*. 1989a). Chargeability contours show an anomaly at a depth of 500–700 m. This was confirmed by drilling which crossed a thick sulphide zone at this depth. The shallow chargeability anomaly is connected with the contact zone between ultrabasic and amphibolite rocks, which contain magnetite and scattered sulphides.

Another important problem of the IP method is to discriminate between high- and low-grade sulphide ores. Recently, spectral IP parameters have been investigated (Alikaj 1989; Langore *et al*. 1989a). We used the Cole–Cole model (Pelton *et al*. 1978) in the time domain to derive the synthetic spectral IP parameters m, τ and C, according to Johnson (1984).

The study of spectral IP parameters was carried out in samples, at test sites and under field conditions. The main conclusion of the study was the good differentiation between massive or veinlet sulphide ores and disseminated sulphide ores. In Fig. 4 a field case history of a spectral IP survey in Derveni volcanogenic rocks is presented. Within the chargeability 'real section' of the M4 window, a strong anomaly of the apparent time constant τ was observed. The first borehole drilled nearby intersected a thick mineralized zone with some intervals of concentrated sulphide belts. However the centre of the anomaly has not yet been verified.

Some results and problems in chrome exploration using geophysical methods

Geophysical investigation, consisting of gravity, magnetic, resistivity and induced polarization methods has provided good results to support the geological mapping of ultramafic rocks and their relationship to the surrounding formations, in order to determine the geology of the mineralized belts and the primary textures of rock massifs (Frasheri 1974; Langore *et al*. 1989b). We present some results of chrome exploration, below.

Over the orebodies, weak gravity anomalies are observed, which are more evident after the field transformation. Figure 5 shows a case study from north-east Albania (Frasheri 1974). It must be noted that such anomalies can also be caused by fresh rock isolations settled among serpentinized rocks. Magnetic surveys may help in some cases to solve this problem. Depending on the orientation of the magnetization and the susceptibility contrast of the orebody, magnetic anomalies can be either negative or positive (Figs 5 and 6) (Lubonja and Kosho 1974; Frasheri 1974). Positive magnetic anomalies have been also recorded over the magnetic serpentinites which contain secondary magnetite due to dynamometamorphism. But these cases differ from those of orebodies because of the lack of gravity anomalies.

In many cases IP anomalies are observed over orebodies consisting of polarizable chromite (Fig. 7) (Lubonja and Frasheri 1966). These anomalies are often wider than orebodies due to a dunitic envelope which presents the same IP parameters as chromite ore. In some cases IP anomalies are also caused by polarizable ultramafic

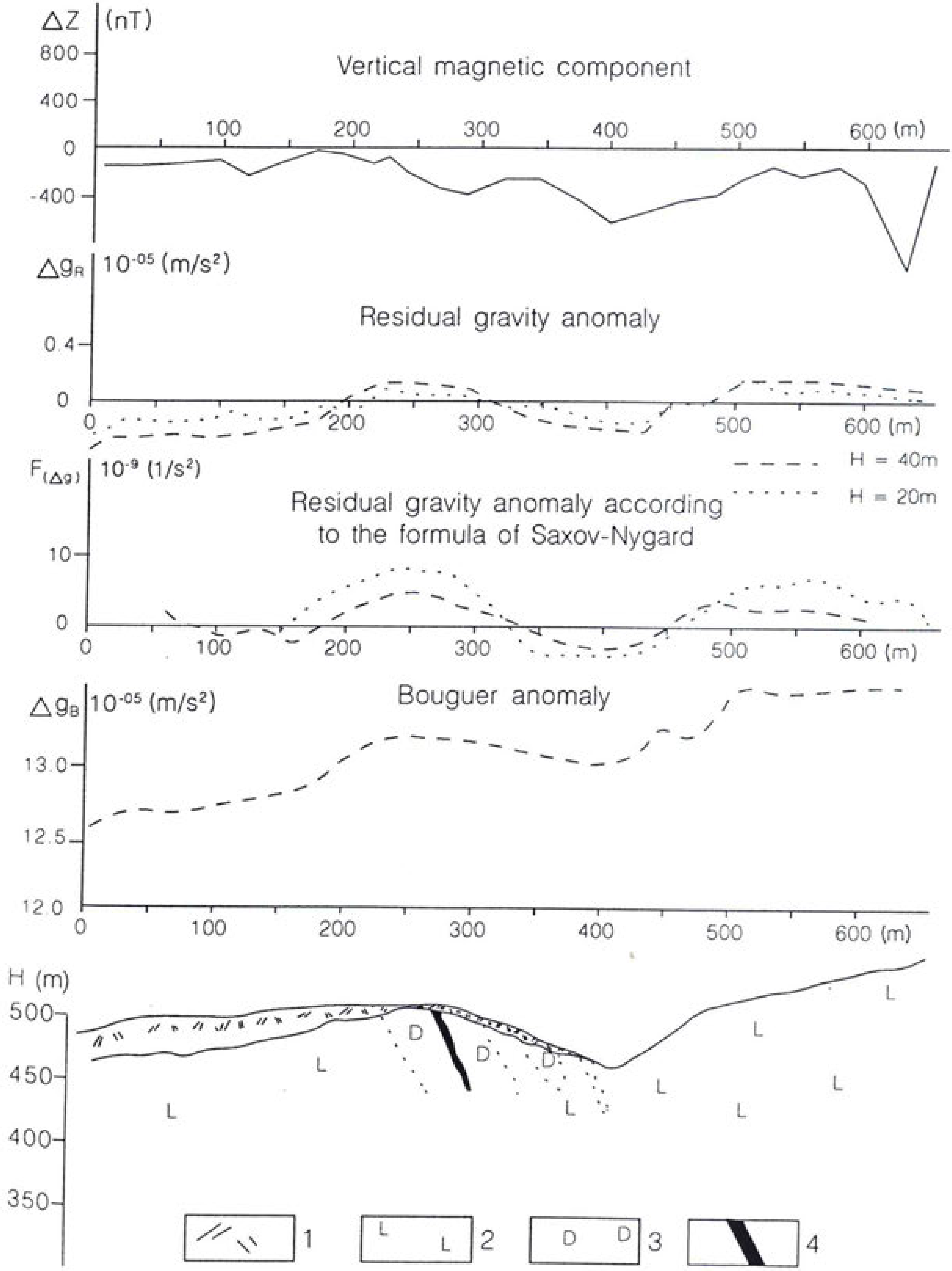

Figure 5. Gravity and magnetic profiles over a chromite orebody. (1) Overburden. (2) Harzburgite. (3) Dunite. (4) Chromite ore.

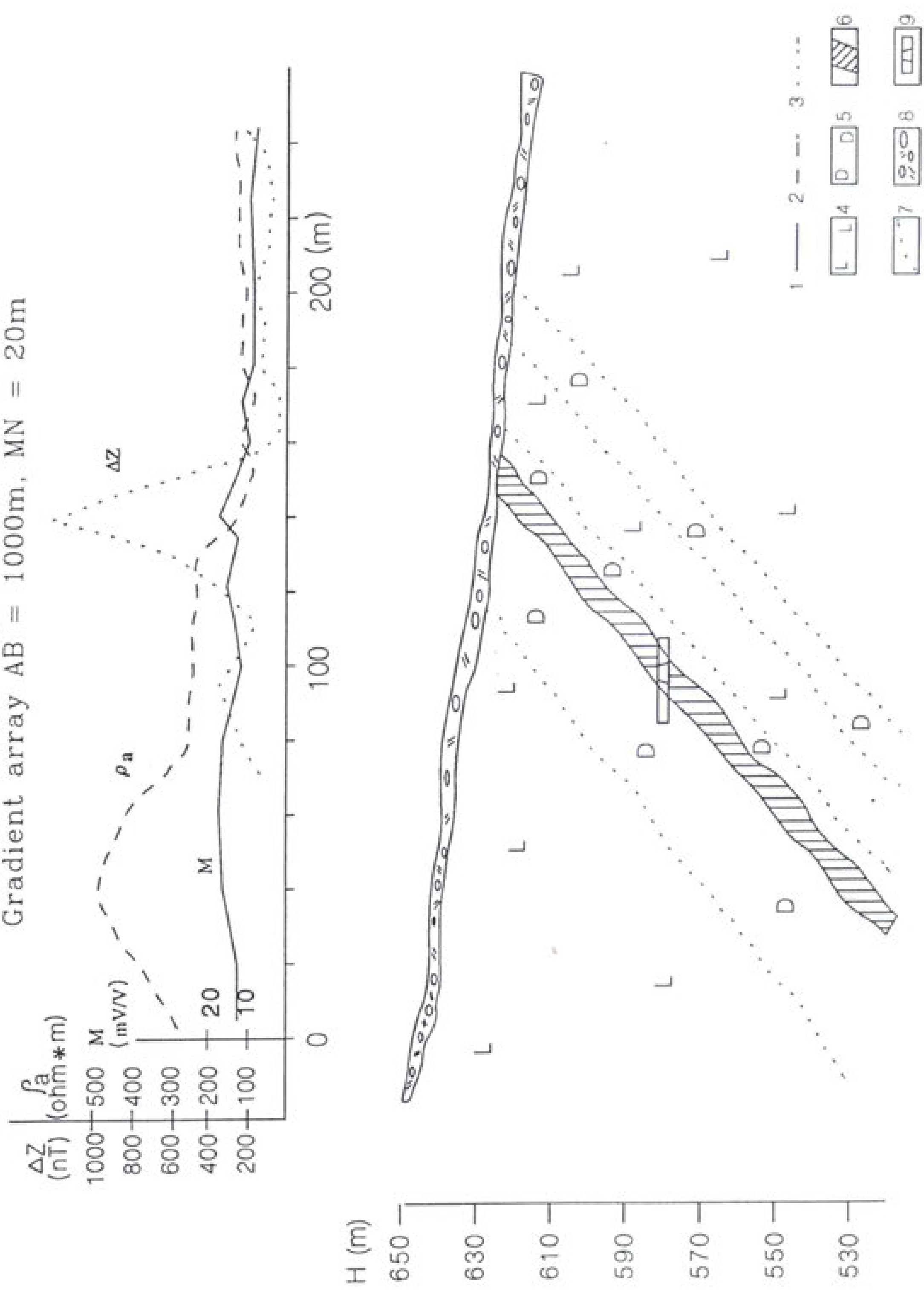

Figure 6. Geophysical profiles and geological section over a chromite ore deposit. (1) IP profile. (2) Resistivity profile. (3) Anomaly of the vertical component of the magnetic field profile. (4) Harzburgite. (5) Dunite. (6) Chromite ore. (7) Gradual geological boundary. (8) Overburden. (9) Mine working.

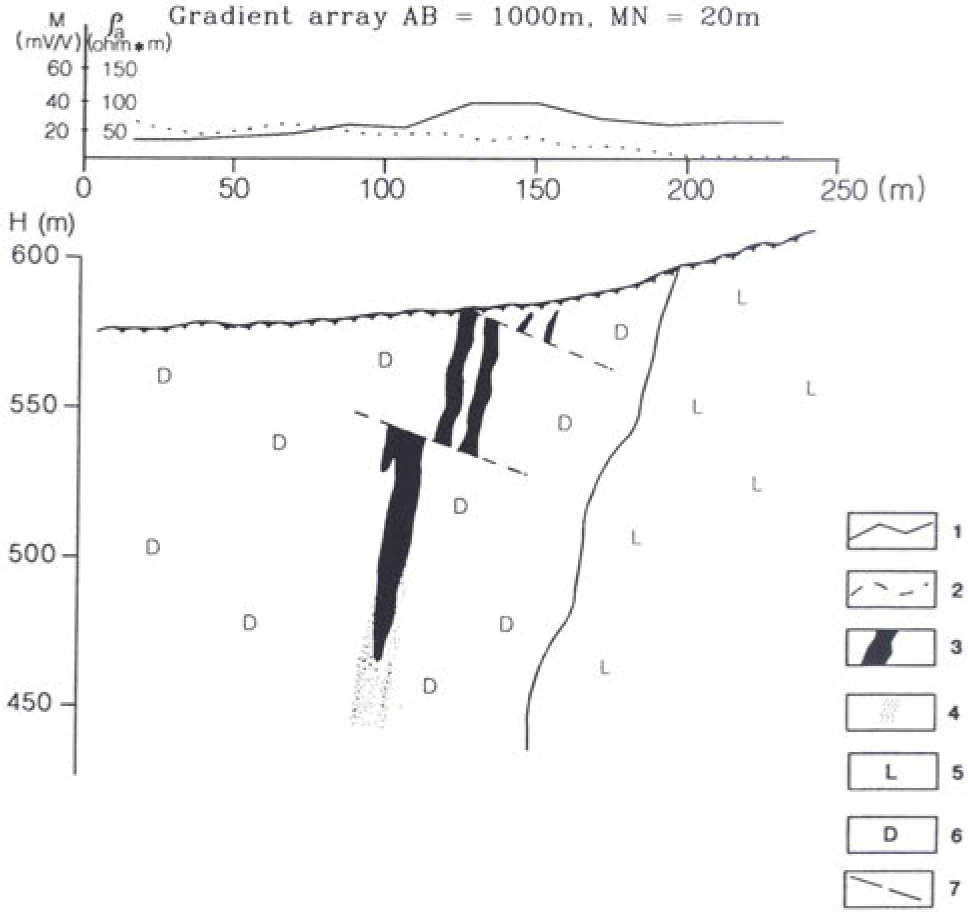

Figure 7. IP and resistivity profiles over a cross-section of a chromitic ore deposit. (1) IP profile. (2) Resistivity profile. (3) Massive chromite. (4) Disseminated chromite. (5) Harzburgite. (6) Dunite. (7) Tectonic fault.

rocks. Some laboratory tests of chromite samples with spectral IP have shown no correlation between Cole–Cole parameters and chrome-bearing.

In our experience of chrome exploration, we have found examples where the distribution of physical fields is very complicated, because the ultramafic rocks are very heterogeneous. In these cases, the 'ore' anomalies may be detected using an integrated interpretation of geophysical and geological data. However, the complicated physical fields render more difficult the data interpretation and decrease its reliability.

In order to increase the depth of exploration for chromite ores, we have successfully used the borehole magnetic survey and hole-hole radio-wave method (Fig. 8) (Gjovreku 1986). In borehole S-17 which did not intersect any orebody, an anamalous sector of the total magnetic field vector **T** at a depth of 190–330 m was observed. This anomaly was interpreted as being caused by a magnetic chromite orebody between the boreholes S-17 and S-16. The shallow boreholes S-1, S-2, S-3 and S-4 drilled at the end of gallery G-5 intersected the predicted orebody.

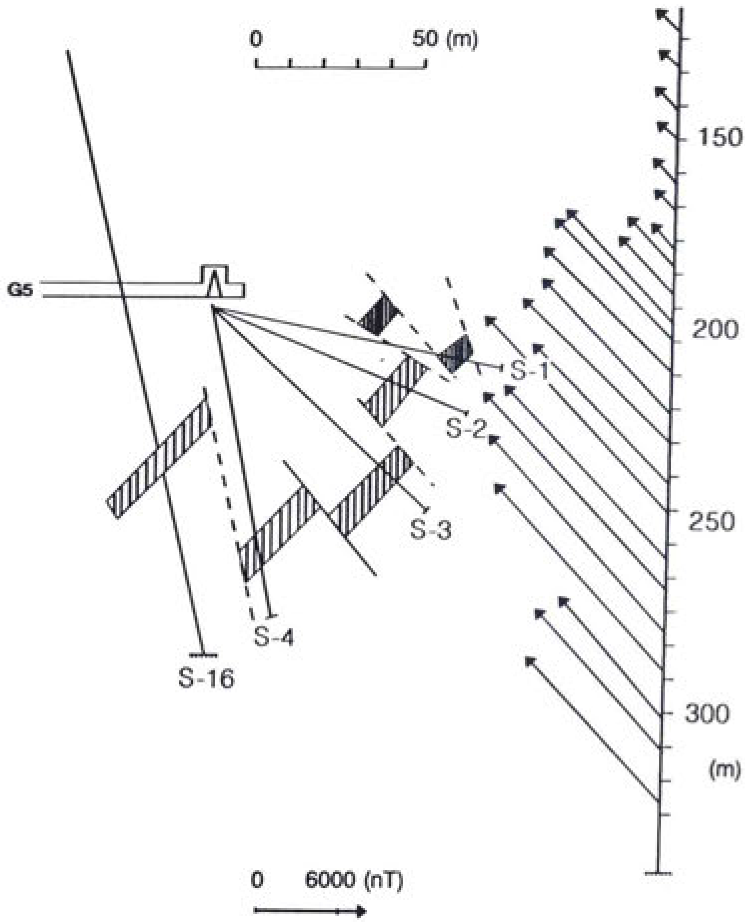

Figure 8. Results of a three-component borehole magnetic field survey in the search for chromite ores. (Anomaly of total magnetic field **T**).

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World Geothermal Congress 1995, May 1995, Florence, Italy.

GEOTHERMAL ENERGY SOURCES IN ALBANIA

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Abstract

The results of geothermal investigations in Albania and the possibilities of exploitation of geothermal energy sources are treated in this article.

The aim of this paper is to present the posibilities for the extension of energetic resource in Albania through the use of geothermal energy.

Geothermal investigations in the past three years have shown there exist possibilities for the exploitation of the geothermal energy in Albania. The ways of exploitation of this kind of energy are also given.

1. INTRODUCTION

Albania is a mountainous Mediterranean country with numerous natural energetic resources. There are many rivers flowing from the mountains where seven hydro-power plants have been built, with an installed power of 1427.1 MW (Frasheri N., 1994)

There are about 20 oil and gas reservoirs under exploitation in Albania, producing about 1.2 Mt oil (Albanian Encyclopedic Dictionary, 1985), but the last years the production is decreased and in 1993 only about 649.8 Kt of oil was extracted.

There are tens of coal mines in Albania, with an output of over 2 Mt coal in 1984 and 214.6 Kt of coal in 1993.

The Albanian energetic system is mainly based on electricity produced by hydro-power plants. The climate of Albania is a typical Mediterranean one, with a hot and dry summer. This climate makes the electrical system (based on the water resources of Albania) very capricious.

In the present conditions of a new Albanian market economy, together with the transformations in the management of existing energetic system, the study of other energetic sources has begun. There are great possibilities to use these sources of energy (about 129.3 $K.kal \cdot cm^{-1} \cdot year^{-1}$). In the coastal areas the average wind speed is about 2.8-3.8 $m \cdot sec^{-1}$ (Climate of Albania, 1978). There are many regions where the wind speed is several times greater than that in the above-mentioned regions. This is another important source of energy.

In Albania there are also many thermal water springs and wells of low enthalpy with a temperature of up to 65.5°C, which indicates that it is possible to make use of the geothermal energy.

2. GEOLOGICAL FEATURES

The Albanides form an integral part of the southern branch of the Mediterranean Alpine orogen. They are subdivided in two zones: the Internal and the External Albanides.

The Internides are formed by the Mirdita ophiolite nappe which is separate from the oceanic Subpelagonian Trough (Geological Map of Albania, scale 1:200,000, 1984)

Geological and geophysical studies carried out in the External Albanides and in the Adriatic Sea display distinct structural

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belts which are related to different tectono-stratigraphic units. From East to West the External Albanides consist of the Krasta-Cukali isopic zone, the Kruja zone, the Ionian zone and the Sazani zone. While in northern Albania the Albanian Alps zone is located.

The Kruja zone is characterized by a 1500m thick Cretaceous to Paleogene neritic carbonates and 5km of Oligocene flysch. Local Tortonian of the continental sandstone facies lies unconformably on a variety of older strata.

The Ionian zone is made up of a thin-sinned forl and thrust belt which is detached from the basement at the level of Permo-Triasic evaporites. Late Triassic and Early Jurassic neritic limestones and dolomites contain cherts. Oligocene and Aquitanian series are developed into flysch and flyschoide facies.

At the base of Burdigalian to Serravalian series, in the clay-marl series of present molassic facies an angular unconformity is developed.

The Preadriatic Depression is filled with continental and deltaic Miocene and Pliocene series. Serravalian sandstones and clay lies unconformably on deformed older strata and are themselves involved in compression structures.

Generally, carbonate rocks are fissured and karstified, thus forming important groundwater reservoirs (Dakoli, H., et al. 1981, Hydrogeological Map of Albania, scale 1:200,000, 1985, Eftimi R et al, 1989).

In the western part of Albania, there are two cartesian basins: Adriatic and Tirana basin. The sandstone aquifer of the Tortonian deposits generally have a low permeability (the medium specific yield of the wells is about 0.04-1 $l \cdot s^{-1} \cdot m^{-1}$.

3. METHODS AND STUDY AREA

Geothermal studies carried out in Albania are oriented toward the study of the distribution of the geothermal field and the natural thermal water springs and wells. The temperatures have been measured and the geothermal gradient and the heat flow density at different depths have also been calculated (Frasheri et al. 1995). Temperature measurements were carried out both in 145 deep wells, in boreholes and in mines, at different hypsometric levels.

The temperature in the wells was recorded at regular intervals. It was measured by means of resistance and thermistor thermometers. The average absolute measurement error was 0.3°C. The measurements were carried out in a steady-state regime of the wells filled with mud or water. The recorded data were processed using the trend analysis of first and second degrees.

The chemical composition of the waters was found. The output of the springs and wells and their hydrogeology was evaluated.

Geothermal studies were extended all over the territory of Albania. In the western regions, where oil and gas reservoirs are situated, the temperature has been recorded in about 120 wells. In the North-East and South-East regions of Albania about 25 boreholes have been studied together with 8 thermal water springs the chemical analyses of which were also carried out.

4. RESULTS

The results of the geothermal studies are presented in maps and geothermal lines. Temperature maps have been drown for different levels of up to 5000m depth. Geothermal gradient maps and heat flow density maps have also been drown. The natural springs with thermal waters and the geological structures with high water temperature have also been mapped. The water basins with higher average temperature than that of yearly average in

one of the regions have been studied as well.

The study of the possibility of exploitation of abandoned deep oil wells as "Vertical Earth Heat Probes" (Frasheri A., Bakalli F., 1995), has already begun.

5. DISCUSSION

The geology of Albanides creates the premises for the research and exploitation of natural geothermal energetic resources (Frasheri A., et al., 1995., Frasheri A. & Bakalli F., 1995).

The greatest heat flow density with a value of 42 $mW \cdot m^{-2}$ is found in the center of the Preadriatic Depression (Fig. 1). In the east of the ophiolitic belt heat flow density reaches values of up to 60 $mW \cdot m^{-2}$.

The temperature varies from a minimum of 12°C at a depth of 100m up to 105.8°C at a depth of 6000m. In the central part of the Preadriatic Depression, there are many deep oil wells where the temperature reaches up to 68°C at a depth of 3000m. The isotherm runs in a direction that fits that of the strike of the Albanides. The configuration of the isotherm is the same down to a depth of 6000m. Going deeper and deeper the zones of highest temperature move in a direction south-east to north-west, towards the center of the Preadriatic Depression and even further towards the north-western coast.

The geothermal gradient has the highest value about 18.7 $mK \cdot m^{-1}$ in the center of the Preadriatic Depression. Elsewhere the gradient is mostly 15 $mK \cdot m^{-1}$ (Fig. 2). In the south of the country the geothermal gradient has low values 11.5-13 $mk \cdot m^{-1}$. The lowest gradient value of 7-11 $mK \cdot m^{-1}$ is found in the deep synclinal belts. Towards the north-eastern and south-eastern regions of Albania, over the ophiolitic belt, the geothermal gradient increases, reaching the value of 23.5 $mK \cdot m^{-1}$.

6. GEOTHERMAL AREAS AND RESERVOIRS

In Albania there are many thermal springs and wells of low enthalpy. Their water has temperatures that reaches values of up to 60°C (Fig. 3).

Table 1 presents some data on the water temperature for such springs.

Table 1

THE THERMAL WATER SPRINGS IN ALBANIA

N° of Springs	Location	Tempe-rature in °C	Salt in mg/l	Artesian Spring yield in l·s-1
1	Llixha Elbasan	60	0.3	0
2	Peshkopi	5-43	9	10
3	Karne-Sarande	34	<10	
4	Langareci-Permet	6-31	>10	
5	Shupal-Tirana	9.5	10	
6	Sarandoporo-Leskovik	6.7	>10	
7	Tervoll-Gramsh	4	10	
8	Mamurras-Tirane	1	26	10

These thermal water springs are mainly near zones of regional tectonic fractures. Generally the water circulates through carbonatic rocks of the structures and evaporitic beds at some kilometers of depth. The water of these springs contain salt, absorbed gas and organic matter.

They are sulfide: methane, iodine-bromium and sulfate types.

In many deep oil and gas wells there are thermal water fountain outputs with a temperature that varies from 32 to 65.5°C (table 2)

Table 2

THE OIL AND GAS WELLS THAT GIVE THERMAL WATER

N°	Well Name	Temperature in °C	Salt in $mg \cdot l^{-1}$	Fontane yield in $l \cdot sec^{-1}$
1	Kozani-8	65.5	4.6	10.4
2	Ishmi 1/b	64	19.3	4.4
3	Galigati 2	45-50	5.7	0.9
4	Bubullima 5	48-50	35	
5	Ardenica 3	38	15-18	
6	Ardenica 12	32		
7	Semani1	35	5	
8	Verbasi 2	29.3	1-3	

These waters comes from different depth levels (800-3000) of limestone reservoirs (wells 1, 2, 3, 4) and sandstone reservoirs (wells 5, 6, 7 and 8).

Until now the thermal waters of the springs 1, 2, 4, 6 and wells 1, 2, 3 in Albania are used only for health purposes. These waters may be used for heating purposes and green houses as well.

7. DIRECTIONS FOR THE EXPLOITATION OF GEOTHERMAL ENERGY IN ALBANIA

The geothermal situation in Albania offers two directions for the exploitation of geothermal energy, which has not been used so far.

- **First,** thermal water springs and wells of low enthalpy
- **Second,** the use of deep doublet abandoned oil and gas wells and single wells for geothermal energy, in the form of a "Vertical Earth Heat Probe". The geothermal gradient of the Albanian Sedimentary Basin has average values of about 18.7 $mK \cdot m^{-1}$. At 2000m depth the temperature reaches a value of about 48°C. In these single abandoned wells a closed circuit water system can be installed. This "Vertical Earth Heat Probe", by means of water conversion, is coupled with the heat transfer from the surrounding rocks downwards, to be finally recovered in the tubes (Hoffman F., et al., 1993).

Actually in Albania the study of the possibilities of exploitation of the geothermal energy has begun.

8. CONCLUSIONS

In Albania, there are several geothermal energy sources that can be used.

Such geothermal energy sources are natural thermal water springs and deep wells with a temperature of up to 65.5°C. Deep abandoned oil wells can be used as "Vertical Earth Heat Probe".

The use of geothermal energy in the Albania must start as soon as possible, in the framework of a separate project, after the compilation of the Geothermal resource Atlas of Albania" in February 1996.

9. ACKNOWLEDGMENTS

The authors express their thanks to the Committee for Science and Technology of the Republic of Albania and the EU Commission of the "European Atlas of

Geothermal Resources" for all the help provided to us for carrying out geothermal resource studies in the Albania. The authors express their thanks also to their colleagues of the Geothermal Team at the Faculty of Geology and Mining of the Polytechnic University of Tirana and of Geophysical Institute at Academy of Sciences of the Czech Republic in Prague, for their help in our studies of geothermal energy. Particular thanks to Prof. Muhamet Doracaj, As. Prof. Rushan Liço, Dr. Nazif Kapedani, Eng. Burhan Çanga, Eng. Enkelejda Jareci. Special thanks to Dr. Suzanne Hurter, Coordinator of "European Atlas of Geothermal Resources".

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FINITE ELEMENT MODELING OF IP ANOMALOUS EFFECT FROM BODIES OF ANY GEOMETRICAL SHAPE LOCATED IN RUGED RELIEF AREA

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Abstract

Modeling of geoelectrical sections is carried out by using finite elements in two cases:
1. Ore bodies with massive texture having contrast of resistivity with surrounding rocks, where modeling is done in 2.5D;
2. Ore bodies with disseminated texture having no contrast of resistivity with surrounding rocks, and modeling is done in 3D.

There ate taken into account two parameters, the apparent resisitivity and induced polarization. The effect of the relief as well as of the global geological structure is taken into account as well. Case stories are presented to demonstrate different effects and the usability of modeling by finite elements.

The results of modeling are presented according to new method of ***real geoelectrical section***, proposed by Ass. Prof. Dr. Perparim Alikaj, and developed recently in QUANTEQ IP Inc, CANADA**.**

The results are a synthesis of many years of working and are further developed least years in collaboration of the authors with QUANTEC IP Inc. CANADA, in a number of projects.

Introduction

Resolving of geophysical problems means a finite iteration of the couple interpretation↔modeling. Theoretical models exist for a number of ideal cases, rarely found in the nature. The problem becomes more complicated when the depth of investigation increases, together with the increase of secondary effects as of the relief and of the geology of sections. In this paper is treated the problem of modeling of geoelectrical real sections by using finite elements to solve elliptic equations in heterogeneous medium related with complex geological situations and rugged relief. This processus is used both for Resistivity and IP modeling.

Principles of application of finite elements in modeling of geoelectrical sections.

The key for modeling of geoelectrical sections is the scattering of electrical field in a heterogeneous geological medium under a rugged relief. For this purpose we have used [Frasheri A. et al., 1984; 1990-94] the elliptic equation in its generalized form, which related weak problem is [Zienkiewicz O., 1977]:

$$\min \int_V [(\nabla W)^T D \nabla U - WQ]\, dv = \int_{S_n} w\, [\underline{n}^T D \nabla U - U_n]\, ds \qquad (1)$$

Where: U is the potential of electrical field; W,w are weight functions; D is the matrix of resistivity; $\underline{n}$ is the unitary normal vector to the boundary S_n; U_n is the Newman boundary condition value.

We solved this problem by using parametric finite elements with four nodes. Normally the geoelectrical section may be considered as a rectangle, the upper part of it deformed corresponding to the relief [fig.1]

The boundary conditions are of type Newman which present power electrodes positioned in two nodes of the upper edge of the rectangle. In the other part of the boundary we normally use Newman conditions zero.

The solution of the problem (1) gives the scattering of the electrical potential in a discrete form. There data need to be interpreted in the right way to give information compatible with that collected during field surveys. We had considered two parameters, the Apparent Resistivity and the Induced Polarization.

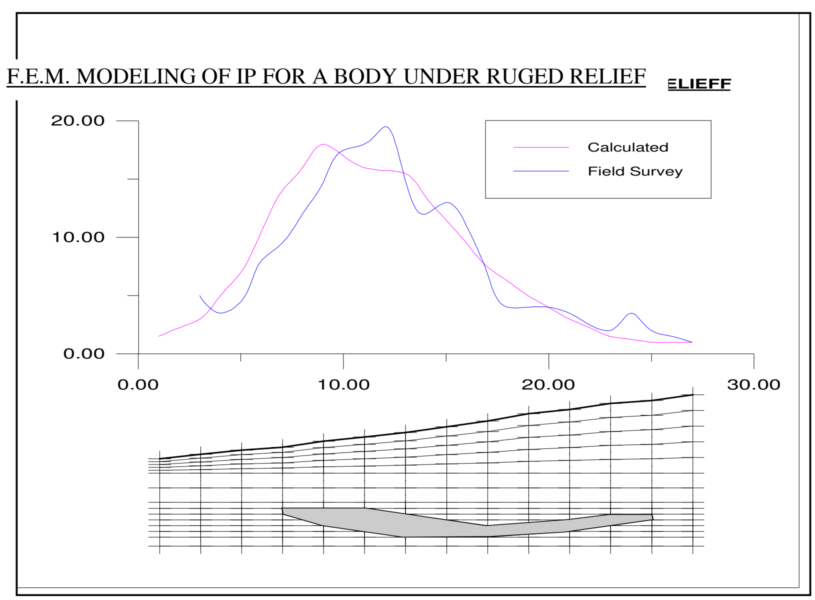

Fig.1. A finite element section of a geoelectrical section in rugged relief.

Modeling of Apparent Resistivity Anomalous Effects.

The meaning of “apparent resistivity” is related with the formulae:

$$\rho_a = \Delta U/\Delta U_o \tag{2}$$

Where: U is the electrical potential of heterogeneous geoelectrical section; U_o is the electrical potential of homogeneous half-space with resistivity 1 Ohm.m.

During the field measurements the U_o is evaluated by theoretical formulae of the electrical dipole:

$$U_o = c\ (1/R_A - 1/R_B) \tag{3}$$

Where: U_o is the potential of the electrical field for the homogeneous half-space; R_A,R_B are distances from the calculation point to the current electrodes A and B.

To carry out mathematical modeling we used two solutions.

First solution was to solve the weak problem two times, one for the heterogeneous case and the other for the homogeneous half-space, having so both discrete approximations of U and U_o for the formulae [2]. The second solution was based on special treatment on the boundary conditions. The real geo-electrical section has to be considered similar to the lower half infinite space, but the ordinary finite element model implies a finite domain as shown in the Fig.1. As consequence the application of theoretical solution for the Uo gives deformed results having a non-negligible error. To avoid this error it is necessary to imply “the infinite” on the finite boundary.

A “classical” solution to imply the infinite is to use “infinite elements”. A case of infinite elements we used for geo-electrical models is treated in [Frasheri N., 1983]. Another solution based on hybrid elements and Furrier transform is given in [Tong, Rossettos, 1978]. A simple solution we used for geo-sections having no important heterogeneous horizontal layered structure. In this case it is possible to evaluate theoretically the normal gradient of the field in the boundary using the formulae:

$$dU/dn = c\ (R_A/R_A^3 - R_B/R_B^3) \tag{4}$$

Where; dU/dn is the gradient of potential of the electrical field; R_A,R_B are distance vectors of the receiving point to the current electrodes A and B.

In this case we simply calculate the flux of electricity on the boundary nodes and add respective values in the right side of the simultaneous linear equations resulting from the problem [1]:

$$[K].[U]=[F] \tag{5}$$

Where: [K] is the master matrix of the system; [U] is the vector of discrete values of the potential U in nodes; [F] is the vector of flux concentrated in boundary nodes.

A comparison of apparent resistivity values over a geo-section with a vertical contact for the theoretical, finite elements and "infinite" elements is given in Fig.2.

Modeling of Induced Polarization Anomalous Effect.

We used the finite element modeling of IP in two ways, related with physical characteristics of geo-sections. The IP phenomena is modeled mathematically as the potential of a double layered surface which represents the boundary between the mineralized homogeneous ore body and the surrounding rocks. In reality mineralized ore bodies have a certain texture, being not really homogeneous. The bodies with disseminated texture have the IP scattered in the volume, and bodies with massive texture have the IP concentrated on its boundary surface. The calculation of IP effect is based on the formulae of Bleil [Bleil D., 1953; Seigel H.O., 1959], as well as evaluation of Komarov [Komarov V.A., 1972] assuming that $C(Uo+Uip) \approx CUo$.

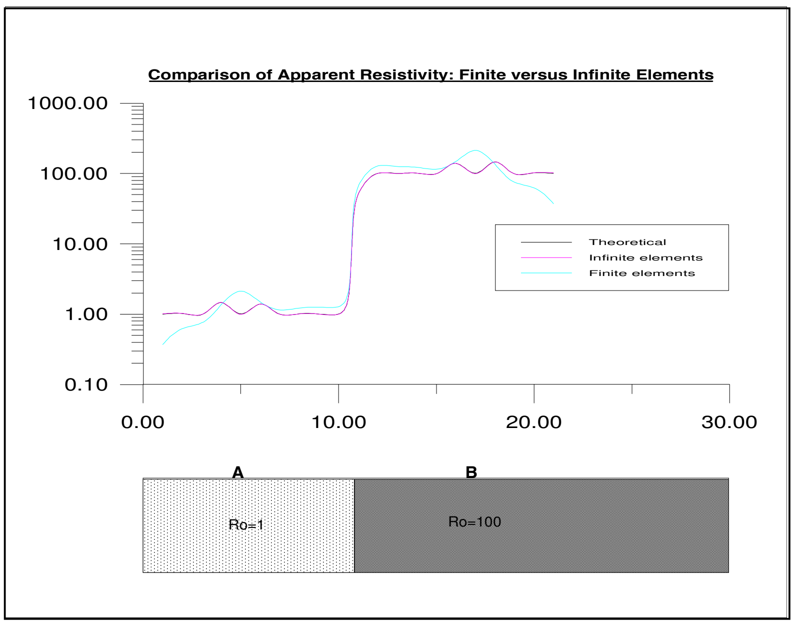

Fig.2. Comparison of theoretical (1), finite elements (2) and "infinite" elements (3) solution for the apparent resistivity anomaly over a vertical contact.

Taking into account the fact that in some cases the heterogeneity of the medium may influence considerably in the IP responses measured at the earth surface, we used 2.5D finite element modeling of IP for heterogeneous medium [Fig.1]. After calculating the potential U of the electrical field, we used the Bleil formulae for the calculation of the IP effect :

$$U_{ip} = c \int_V \nabla U \, (1/R) \, dv \qquad (6)$$

Where: U_{ip} is the potential of induced polarization;

R is the distance vector from the integration point to the receiving point; ∇U is the potential gradient of the primary electrical field, calculated by solving the finite element model.

For 3D modeling of bodies with massive texture in homogeneous medium we used the Bleil formulae, transformed using Green's formulae:

$$U_{ip} = c \int_S (1/R)\,(dU/dn)\,ds \tag{7}$$

Where: R is the distance vector from the integration point to the measurement point; dU/dn is the gradient of the primary electrical potential on the boundary S of the body, calculated as in the formulae [4].

The integral is numerically calculated using the concept of finite elements for the boundary of the body, and using the standard numerical integration methods for the finite elements, defining automatically the number of integration points on the basis of relative size of elements [Fig. 3].

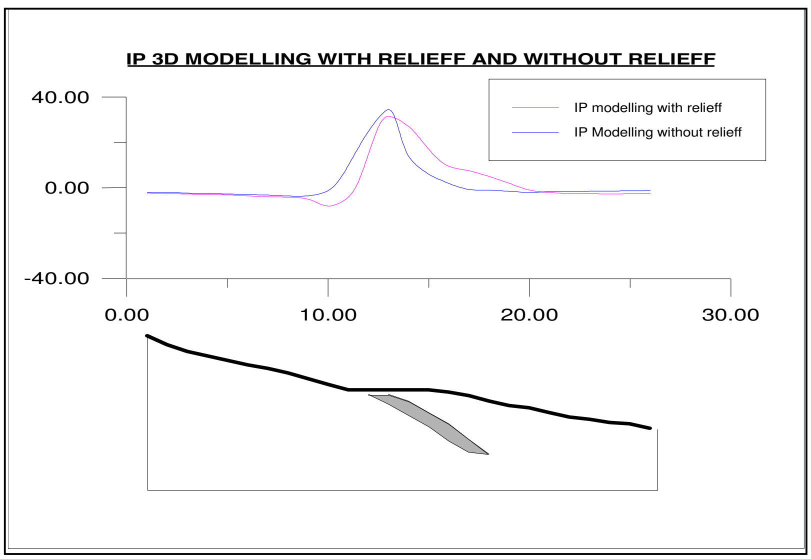

Fig.3. The 3D modeling of IP anomalous effect.

Being already a classical theory, finite elements continue to give way to new aspects of development and application of geophysics. Finite element modeling of complicated geological situations is necessary not only as a proof of the correctness of the interpretation of field data, but also it is very important for the development of new concept and techniques, as it is the "real section" [Langore L., 1989] and special methodologies for field surveys. A typical IP real section modeling is presented in the [Fig.4].

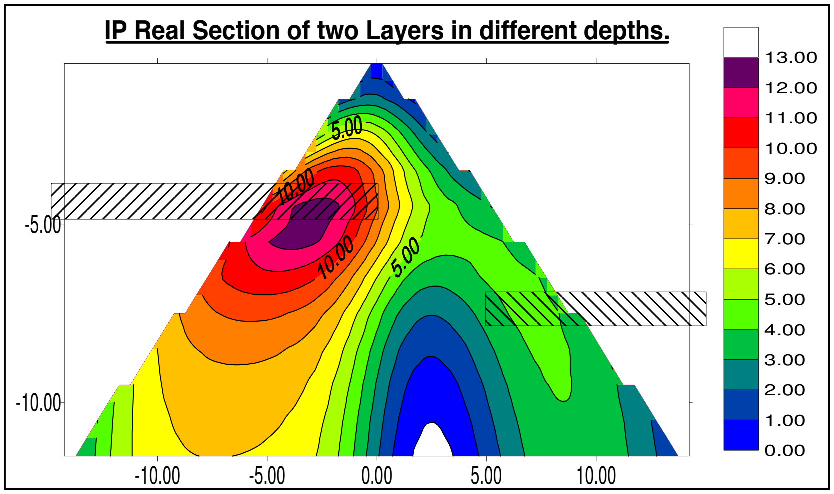

Fig.4. IP real section of two layers in different depths.

4. **Conclusions.**

Finite elements represent a good tool for the modelisation of complicated geo-electrical sections, characteristic of the Albanian geology. It permitted in a number of cases to evaluate correctly the influence of effects of rugged relief and of geology as layered mediums, contacts and faults to the anomalies of ore bodies or mineralized zones.

Real geoelectrical sections, created using the methodology presented also in the paper, offer a sure way for the interpretation of field data. Moreover, real sections have shown the existence of many problems related with the interpretation of field data, and the necessity of special studies to solve these problems.

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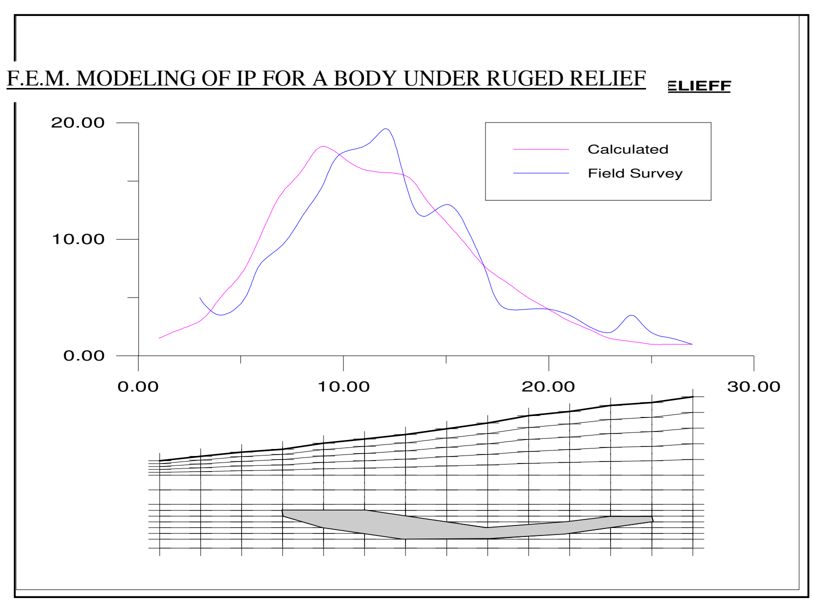

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A comparison of apparent resistivity values over a geo-section with a vertical contact for the theoretical, finite elements and "infinite" elements is given in Fig.2.

Modeling of Induced Polarization Anomalous Effect.

We used the finite element modeling of IP in two ways, related with physical characteristics of geo-sections. The IP phenomena is modeled mathematically as the potential of a double layered surface which represents the boundary between the mineralized homogeneous ore body and the surrounding rocks. In reality mineralized ore bodies have a certain texture, being not really homogeneous. The bodies with disseminated texture have the IP scattered in the volume, and bodies with massive texture have the IP concentrated on its boundary surface. The calculation of IP effect is based on the formulae of Bleil [Bleil D., 1953; Seigel H.O., 1959], as well as evaluation of Komarov [Komarov V.A., 1972] assuming that C(Uo+Uip)≈CUo.

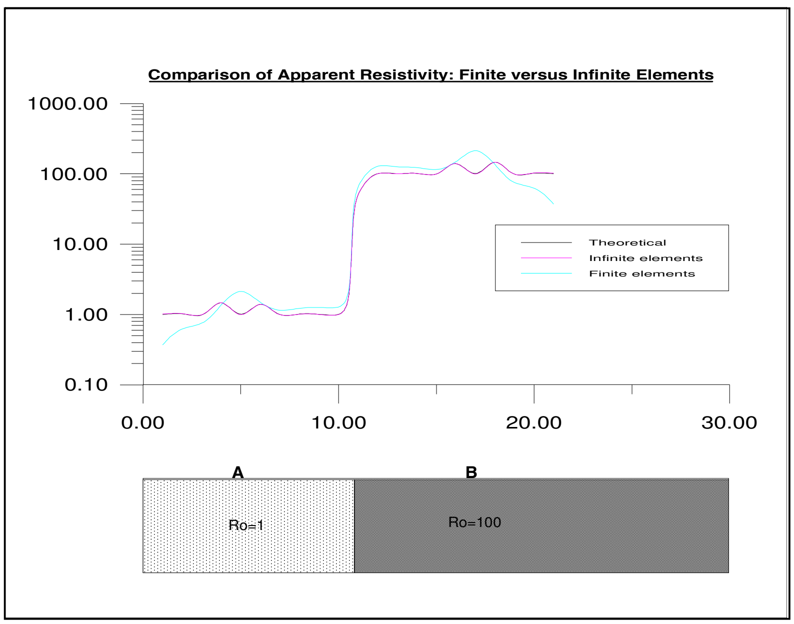

Fig.2. Comparison of theoretical (1), finite elements (2) and "infinite" elements (3) solution for the apparent resistivity anomaly over a vertical contact.

Taking into account the fact that in some cases the heterogeneity of the medium may influence considerably in the IP responses measured at the earth surface, we used 2.5D finite element modeling of IP for heterogeneous medium [Fig.1]. After calculating the potential U of the electrical field, we used the Bleil formulae for the calculation of the IP effect, :

$$U_{ip} = c \int_V \nabla U \,(1/R)\, dv \qquad (6)$$

Where: U_{ip} is the potential of induced polarization;
R is the distance vector from the integration point to the receiving point;
∇U is the potential gradient of the primary electrical field, calculated by solving the finite element model.

For 3D modeling of bodies with massive texture in homogeneous medium we used the Bleil formulae, transformed using Green's formulae:

$$U_{ip} = c \int_S (1/R)\,(dU/dn)\, ds \qquad (7)$$

Where: R is the distance vector from the integration point to the measurement point; dU/dn is the gradient of the primary electrical potential on the boundary S of the body, calculated as in the formulae [4].

The integral is numerically calculated using the concept of finite elements for the boundary of the body, and using the standard numerical integration methods for the finite elements, defining automatically the number of integration points on the basis of relative size of elements [Fig. 3].

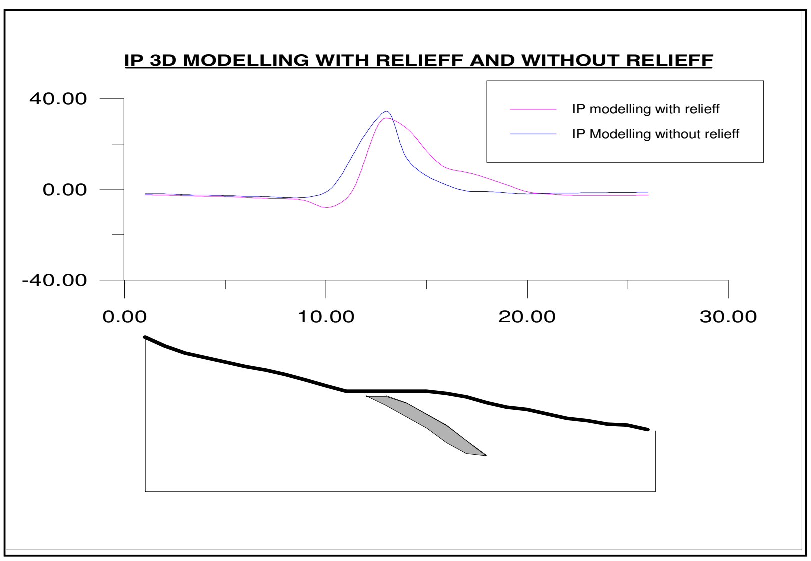

Fig.3. The 3D modeling of IP anomalous effect.

Being already a classical theory, finite elements continue to give way to new aspects of development and application of geophysics. Finite element modeling of complicated geological situations is necessary not only as a proof of the correctness of the interpretation of field data, but also it is very important for the development of new concept and techniques, as it is the "real section" [Langore L., 1989] and special

methodologies for field surveys. A typical IP real section modeling is presented in the [Fig.4].

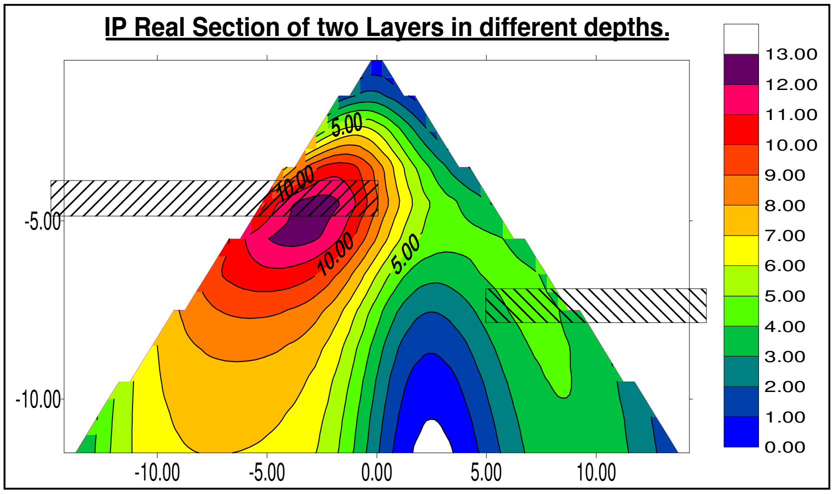

Fig.4. IP real section of two layers in different depths.

4. **Conclusions.**

Finite elements represent a good tool for the modelisation of complicated geo-electrical sections, characteristic of the Albanian geology. It permitted in a number of cases to evaluate correctly the influence of effects of rugged relief and of geology as layered mediums, contacts and faults to the anomalies of ore bodies or mineralized zones.

Real geoelectrical sections, created using the methodology presented also in the paper, offer a sure way for the interpretation of field data. Moreover, real sections have shown the existence of many problems related with the interpretation of field data, and the necessity of special studies to solve these problems.

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O9-3	IP ANOMALOUS EFFECT CONDITIONED BY RUGGED RELIEF AND ORIENTATION OF THE POLARIZING CURRENT VECTOR

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The largest part of the territory of Albania is mountainous. The deposits of solid polarizable minerals as copper, chromites etc. are located in the ophiolitic belt situated in mountain regions characterized by rugged relief. Such geomorphologic conditions and the morphology of ore bodies itself condition the configuration and the amplitude of IP anomalies.

The effect of these factors is studied using physical models, 2D and 3D mathematical finite element models, and the results are compared with the data from field surveys as well. In this paper there are analyzed some results of mathematical models for irregular shaped ore bodies under rugged relief. These results are presented in IP Real Sections.

The 3D mathematical models are based on the assumption that the polarizing currents are distributed in a homogeneous half-space. To take into account the contrast of resistivity between prismatic bodies and the environment we modify the polarizability of the body to include the effect of virtual currents generated because of the contrast of resistivities. Finite elements are used to calculate the effect on the surface of IP generated on the surface of the body by polarizing currents. In the case of 2D models there is supposed that the polarizability is distributed within the volume of the body. Finite elements are used to calculate the density of the polarizing gradient within the body. The environment may be heterogeneous, as well as the effect of the relief is included both for polarizing and polarized currents.

Modeling is carried to evaluate the effect of two factors deforming the IP anomalies:

1. Rugged relief - the target bodies are located under mountain crests, valleys and slopes.
2. Position of target bodies relative to current electrodes of gradient arrays.The rugged relief do influence in two ways. The relief creates variations in the distribution of the polarizing currents and its gradient on the surface of polarizable bodies, modifying the configuration of IP phenomena around the body. But at the same time the relief modifies the scattering of IP currents, influencing the values measured on the surface of the terrain. As result, the anomalies may have deformations both in amplitude and configuration.

For a vertical targets situated under a valley the anomalies have increased compared with case of the flat relief. Under crests the amplitude may decrease and, depending on the depth of the body, its configuration may change even to a bi-modal one. The sides of anomalies may be deformed as well, but generally they remain symmetric. In cases of non-vertical targets under valleys the anomalies are asymmetric with lower amplitudes, as result of the decrease of polarization current gradient on the surface of the body. In cases of targets with small cross-section under crests the negative sides of the anomalies have higher amplitudes, as result of the position of the body relative to the surface.

The orientation of the polarizing current vector do influence directly on the configuration of the IP phenomena around the body, and the typical case is when the target is situated near one of polarizing current electrodes. Even in a flat relief the anomalies may be strongly deformed. By putting the electrode near the body, the anomalies became asymmetric with lower amplitudes. The asymmetry increases until the electrode goes over the body, in which case the anomaly becomes bi-modal with a zero, value over the body having amplitude almost the half of the symmetrical case. The presence of rugged relief in such cases may cause even more strange deformations of the anomalies. The rugged relief itself may condition the position of the current electrode near the body.

In the paper there are presented a number of typical cases from numerous models. Understanding these models and related phenomena would help to assure a good interpretation of the field data, obtaining correct localization of ore bodies and their spatial position. The results of modeling are confirmed by physical models and field examples from IP geoelectrical surveys in Albania, as well as from the field works of the Canadian Company QUANTEC IP.

The Leading EDGR, U.S.A.

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SEISMIC AND GEOELECTRIC TOMOGRAPHY RESULTS IN CONCRETE AND ROCKFILL DAMS IN ALBANIA

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Abstract

Results of seismic and geoelectric tomography in two large dams of Hydroelectro Power Plants in Albania are presented in the paper. These Hydroelectro Power Plants have an installed power 5 MW up to 600 MW. Their dams have a crest length up to 500 meters and maximum height of 165 meters. The dams have been in situ investigated by geophysical methods during the period 1995-1998. The results of these investigations and the technical data on the stability of the constructive materials and rocks will be used to apply the modern dynamic methods for re-estimation of the stability of the hydrotechnical construction.

1. Introduction

Albania has numerous and biggest dams belonging to the hydroelectric power system. These dams are made of concrete and/or rockfill with central clay core. Bigger hydrotechnical work in Albania, the Fierza Hydroelectro Power Plant, has an installed power of 500 MW. The volume of water in its artificial lake is 2.7 billion m^3 (Hydropower Plant Executive Projects, 1953-1988). This hydrotechnical work composed of several constructions. The rockfill with central clay core dam is the biggest assemblage therein. The dam has a crest length of 500 meters and maximum height of 165 meters. In Albania have been constructed also about 600 dams for the reservoirs of the irrigation system, constructed in a short period of about 30

years. The height of their clay dams varies among 10 and 40 meters, while the crest length of the dams goes up to 3 500 meters.

The exploitation of hydrotechnical work over the last 15 to 40 year has influenced the modification of their physical- mechanical properties and constructive structure. Under present conditions, the re-estimation of the stability of the hydrotechnical construction was necessary. In this case, the acquisition of geophysical data on the stability of the constructive materials and rocks was very important in order to apply the modern dynamic methods of such re-estimation. These data were extracted from the in-situ geophysical investigation, which had to go through the following steps (Frasheri A. et al., 1998):

1. Investigation of constructed material which the dam was build up:

1.1. The studies of the structure of the construction material,

1.2. The determination of its physical-mechanical properties.

1.3. The evaluation of the variation of these properties in times.

2. The estimation of slope stability and the study of landslides in the lakeside.

3. The investigation of the grout curtain under the dam in riverbed.

4. For the future is planned: the estimation of the remnant deformations of the dams, monitoring of the dams and the active landslides, the study of lake fillings with alluvium sediments.

Large number of case histories analyzed from various objects is analyzed in the paper.

1. Methods

A complex of geophysical methods was applied for in-situ investigation of the dams (Frasheri A. et al., 1998, Robert C. Benson et al. 1983). Seismic tomography of concrete along the galleries of the dam, and between the galleries and dam top surfaces was carried out. The tomography was combined with refraction seismic profiling of high frequencies on the top surfaces of the dam, and in galleries of the concrete dams as well. The quality of the grout curtain under the dam in the riverbed was investigated in situ on the gallery floor. Geophones lines with lengths from 0.5-43 meters, according to the object’s size and the required depth investigation were used for the seismic observation. Creation of the seismic waves was

performed by mechanical source. A seismic 12-channel station ECHO-2 of Canadian Firm SCINTREX was used to make the recording. Records were made by the company's software package. According to the surveys' data the velocity of P-waves (Vp) and S- waves (Vs) were calculated, as well as the layer thickness. According to all the seismic data, the physical-mechanical properties were calculated for the soil, rocks and concrete of the dams such as Poisson coefficient, elasticity dynamic modulus of, Bulk modulus, rigidity modulus and module of compression volume strength.

Geoelectrical tomography to investigate the clay core of the dam's raw materials was carried out. Resistivity Realsection of the Geoelectric tomography were performed by multiple spacing gradient arrays, with maximal spacing up to AB = 360 m, which provided a survey depth of 50 to 70 m. Profiling was performed in four depth investigations, according to the required depth investigation for each object.

Alongside in the downstream area of raw materials, self-potential surveys were also carried out, in order to study the water filtering process through it.

3. **Discussion of the results**

The seismic and geoelectric tomography results presented in this paper was carried out for dams investigation of Ulza and Vau Dejes Hydroelectro Power Plants (Frasheri A. et al. 1998). Ulza Hydroelectro Power Plant, constructed in 1957, has an installed power 25.6 MW (Executive Project, 1953). The Ulza concrete dam has a crest length of 340 meters and maximum height of 131 meters (Photo 2). Vau Dejes Hydroelectro Power Plants, constructed in 1971, has an installed power 250 MW (Executive Project, 1967). Two sections compose Qyrsaqi dam in Vau Dejes: Concrete section (1) and gravelfill with central clay core section (2) (Photo 1). The dam has a crest length of 480 meters and maximum height of 79 meters. Geoelectric tomography was performed only in the raw materials section of this dam.

In-situ geophysical investigations were carried out in order to resolve a wide specter of duties in several objects.

Evaluation of the concrete physical-mechanical properties

Tomography data at 30 m and 53.5 m in the concrete section of the Qyrsaqi dam showed that, generally, the concrete has a characteristic wave velocities of greater than Vp=4000 m/sec and Vs=1900 m/sec (Fig. 1). But, at the left dam edge, an area where the Vp decreases to less than 4000 m/sec exists. The fact that, together with the P-waves velocities, the S-waves velocity decreases, shows that in this sector, the concrete has weaker physical and mechanical properties.

It is not enough to use only the seismic tomography among different galleries, because this leads to deficiencies in results and incorrectness in details. These results were compared with the supplementary seismic profiling on the concrete structure, especially in superficial spots. The concrete bottom of inspection galleries in Qyrsaqi dam also has good physical-mechanical properties. But in some sectors of the galleries, a superficial layer of some centimeters to 1 meter is attached, which mechanically is weak (Fig.2, 3, 4). The mechanically weak concrete layer shows that the concrete will deteriorate under the water's effect, or the cementing in these sectors was made by poor quality concrete. The surveys and tests we are going to develop further on will resolve this alternative.

In the Ulza Dam (Fig. 5, 6), results from the seismic tomography survey indicates that the concrete in general is also characterized by high velocities of the seismic waves propagation Vp= 4300-5035 m/sec and Vs= 2412-2429 m/sec. The elasticity dynamic modulus is $(3.27\text{-}3.60)\times 10^5$ kG/cm^2. According to the tomography data, it is noticed that at the upper levels of dam , the longitudinal wave velocities Vp are, on average, higher than the lower levels . At the same time, at both levels, the transversal wave velocities are equal. In addition to that, the average square deviation of transversal wave velocity is almost twice less than the longitudinal wave deviation. These facts are an argument that the decrease in velocity and high fluctuations in velocities impacts on water penetration into the concrete pores. The velocities (Vp) in the lowest levels are lower than in the upper levels, as a result of being under constant high water pressure. The concrete of lower levels also contains more water. The mechanical properties of this concrete are also weaker than the upper levels. Considering the concrete mark 250 for lower levels (Dzievanski J. et al., 1981), based on the calculated

physical-mechanical properties, the upper levels have concrete of higher value than 250, because the elasticity dynamic modulus is 3.96 x 10^5 kG/cm^2. In the tomogram it is possible to define a sector which characterized with physical-mechanical properties lower than the surrounding environment. Within this sector, the main water filtering of the gallery of lower level is observed.

Even at the dam of Ulza the inner walls of the inspection gallery, as well as in dam surface, have a low elasticity dynamic module, up to 74.000 kG/cm^2 (Fig. 7). At this sector, several filtration of Lake Water are evidenced in the inner of dam. This state of concrete at the Ulza dam shows once more the impact of "ageing" phenomena on concrete

Evaluation of the soil and rocks physical-mechanical properties

The clay material has a lower resistivity at the center and western edge of Qyrsaqi dam than the eastern edge (Fig. 8, 9). The seismic wave velocity is lower in this sector, too. The water filtering into the clay's core explains this.

The average electric resistivity of the dam's core is about 100 Ohmm. However, in 5 sectors of the dam's core, this resistivity decreases up to 25 Ohmm in spots. As it is shown at the Resistivity Realsection, these anomalous spots are located at 3 m depth to 45 m from the level of dam's top surface (Fig. 4). It is evident that three of these anomalies coincide horizontally. The anomaly, which happens under the station ST. 20, initiates from 22 m depth and continues to 45 m, has a vertical extent, and dips toward the west.

The seismic tomography section shows that, beneath the superficial layer at the top of the dam, which has a thickness of 2–10 m and low velocities of seismic waves, (respectively Vp=1080 m/sec and Vs=550 m/sec), there is a second clay layer (Fig. 8). This layer of clay has a thickness of 4 – 21 m, increasing in thickness towards the west, where the ground dam meets the concrete part of the dam. The velocities of seismic waves are lower in western dam sector. The clay's core, under the second layer, is characterized by higher seismic waves velocities (up to Vp=2200 m/sec and Vs=800 m/sec). The elasticity dynamic module, calculated according to Vs data, varies from (0.04-0.88)*10^5 kG/cm^2 for the second clay

core. Based on the geophysical investigation results, shown above, the areas with a lower electric resistivity and lower velocities of seismic waves than the other part of the dam’s core, are interpreted to be due to water filtering through the clay core. This interpretation does not exclude the possibility of heterogeneity of the clay’s material during dam’s construction .The increase of velocities of the seismic waves toward depth shows than the clay’s core is compacted. The configuration of seismic waves velocity contours in the section shows normal bedding of core’s material, with western dip. The study of these dangerous phenomena brings the necessity of monitoring the dam through geophysical methods, along with all other installed equipment from the Geologic-Technical Service of Hydropower Plant. Some periodic investigation over many years are necessary in order to observed the changes in time of electric resistivity and the seismic waves velocities.

4.Conclusions

1. Concrete used to build hydroelectric power plant dams in Albania has different physical-mechanical properties, thus diverse technical state from each other. The higher quality of concrete is found in Qyrsaqi dam of the Vau Dejes Hydroelectric Power Plant. The lowest quality concrete is observed in Ulza dam.
2. At the dams of Qyrsaqi and Ulza Hydroelectric Power Plants, the existence of superficial concrete layers, up to 1 meter thick, are observed. These have very poor physical-mechanical properties.
3. In the central and western part of the clay core at Qyrsaqi dam, there are observed some sectors with low values of electric resistivity and velocities of seismic waves, more than at the side parts of the dam. The increases in physical properties are interpreted to result from water infiltration to the clay’s core

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Robert C. Benson, Robert A. Glaccum, Michael R. Noel. 1983, Geophysical Techniques for Sensing Buried Wastes and Waste Migration., Band 1, Band 2. United State Environmental Protection Agency. Environmental Monitoring System Laboratory, Las Vegas, Nevada 89114.

Photo.1

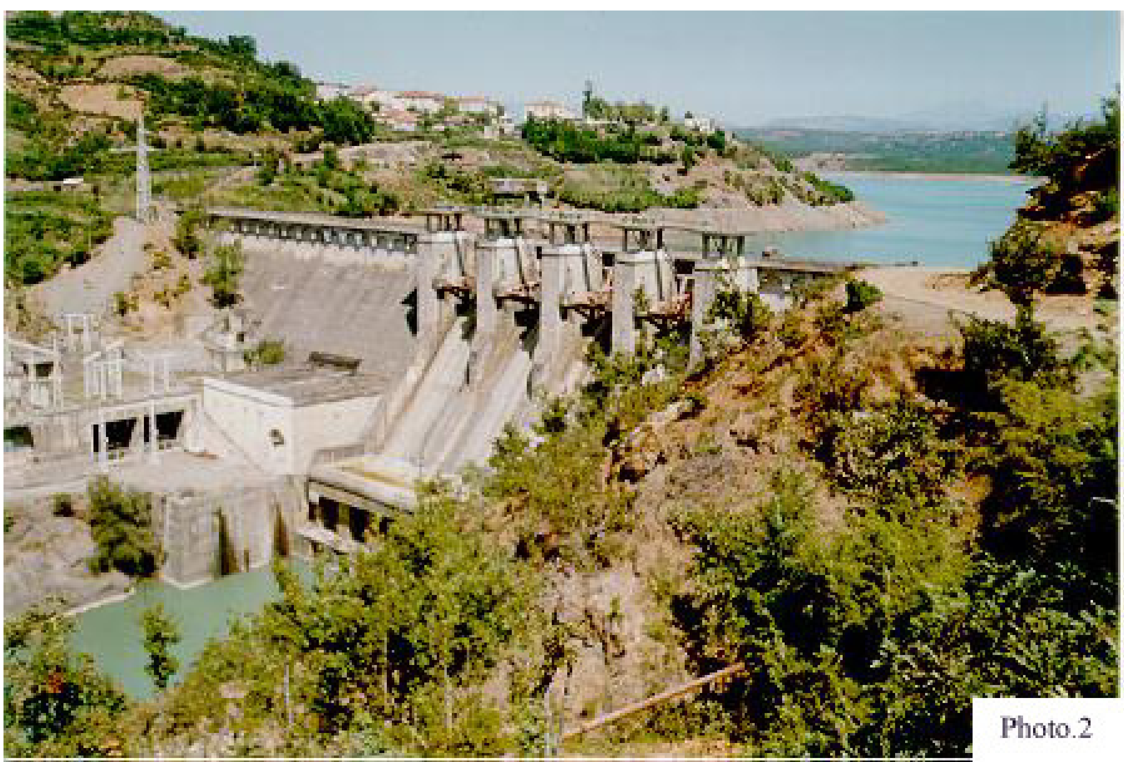


Photo.2

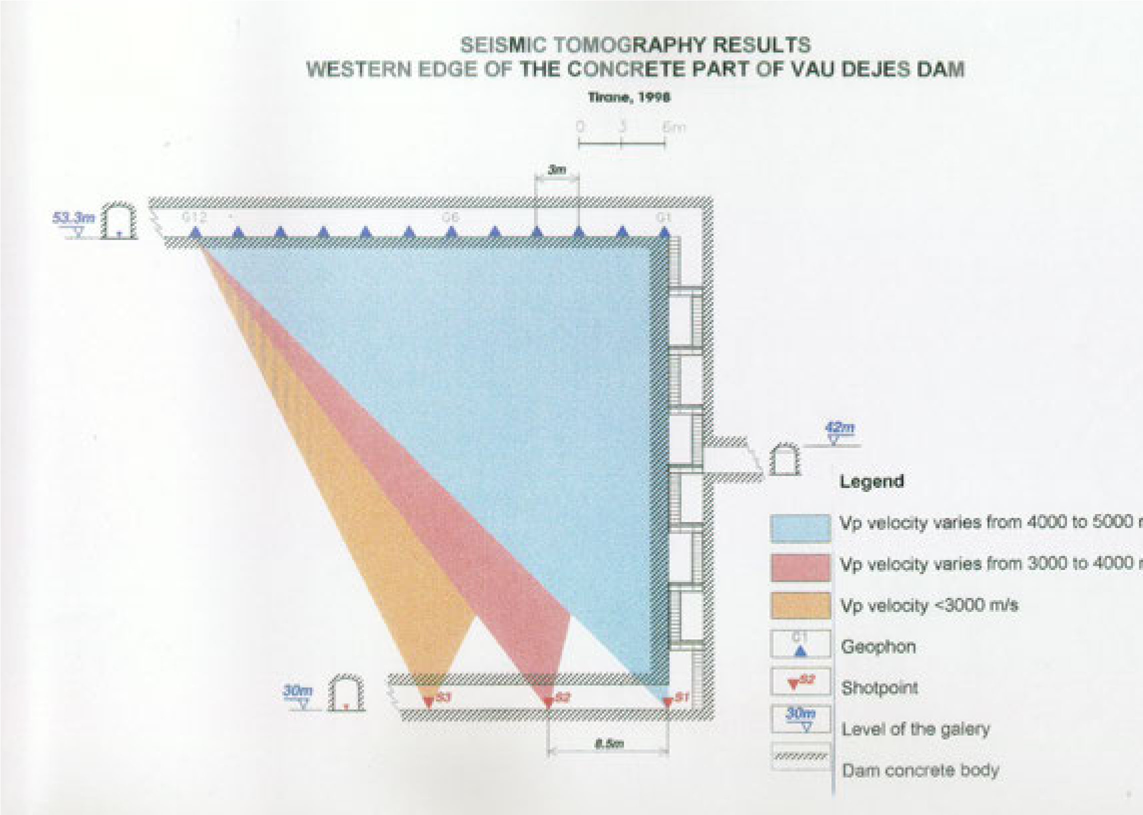

SEISMIC TOMOGRAPHY RESULTS
WESTERN EDGE OF THE CONCRETE PART OF VAU DEJES DAM
Tirane, 1998
0 3 6m
3m
53.3m
G12
G6
G1
42m
30m
S3
S2
S1
8.5m
Legend
Vp velocity varies from 4000 to 5000 m/s
Vp velocity varies from 3000 to 4000 m/s
Vp velocity <3000 m/s
Geophon
Shotpoint
Level of the galery
Dam concrete body

Fig. 1

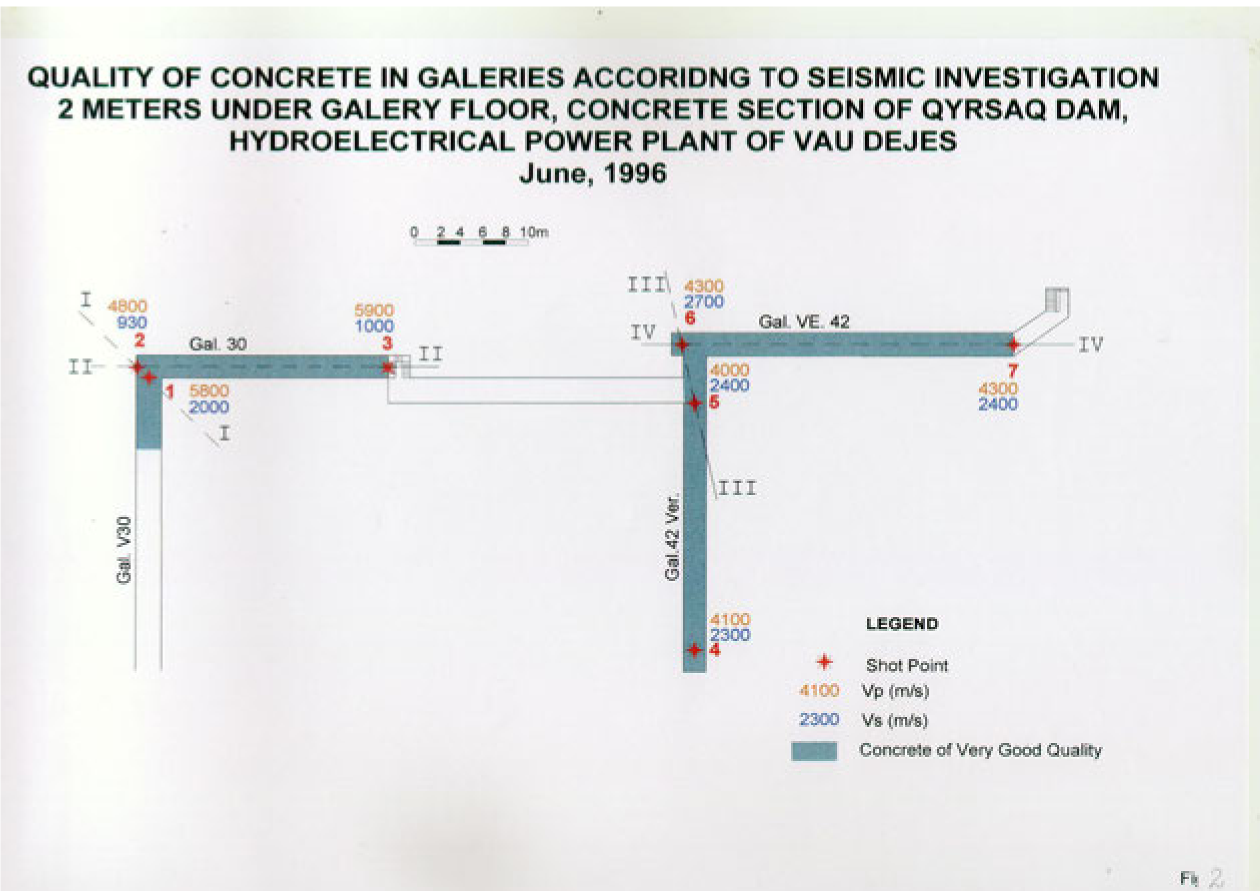
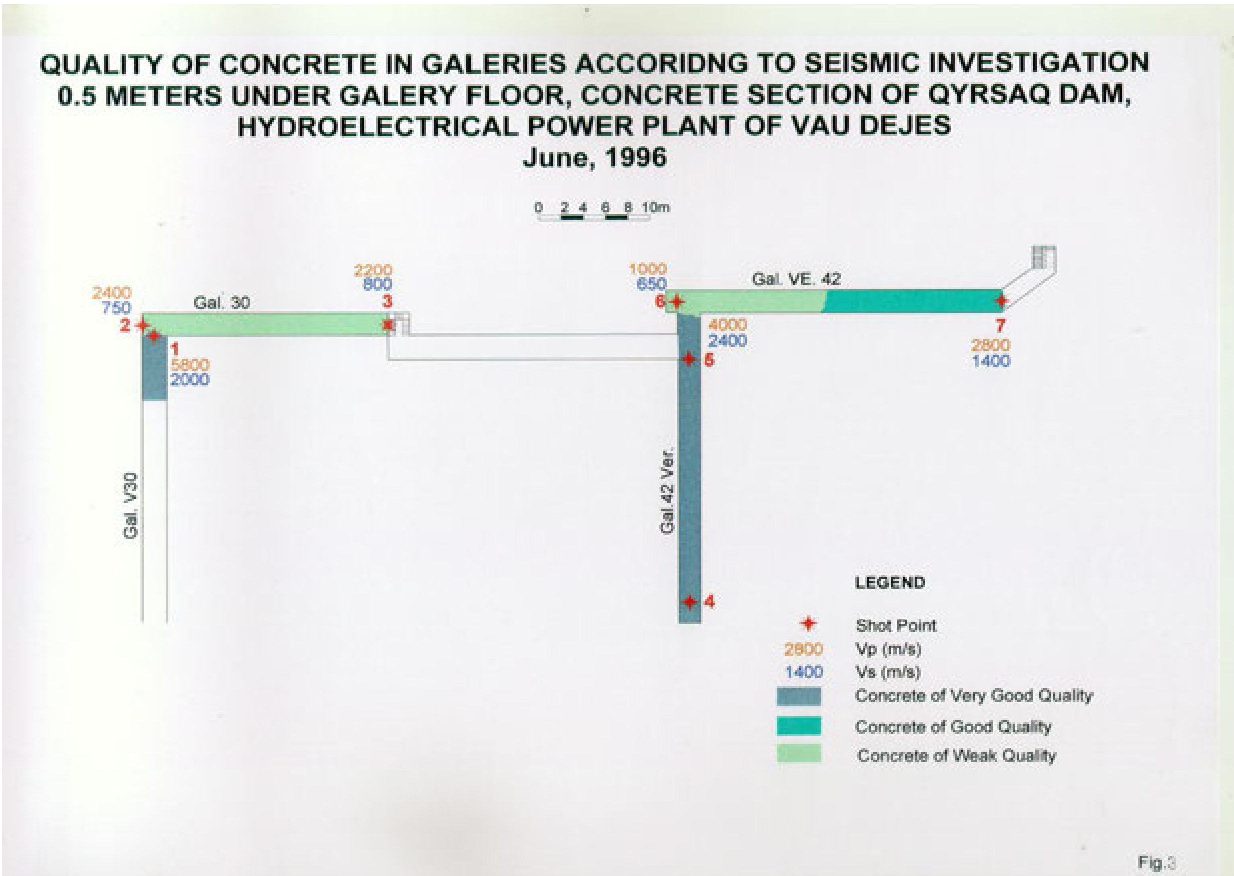
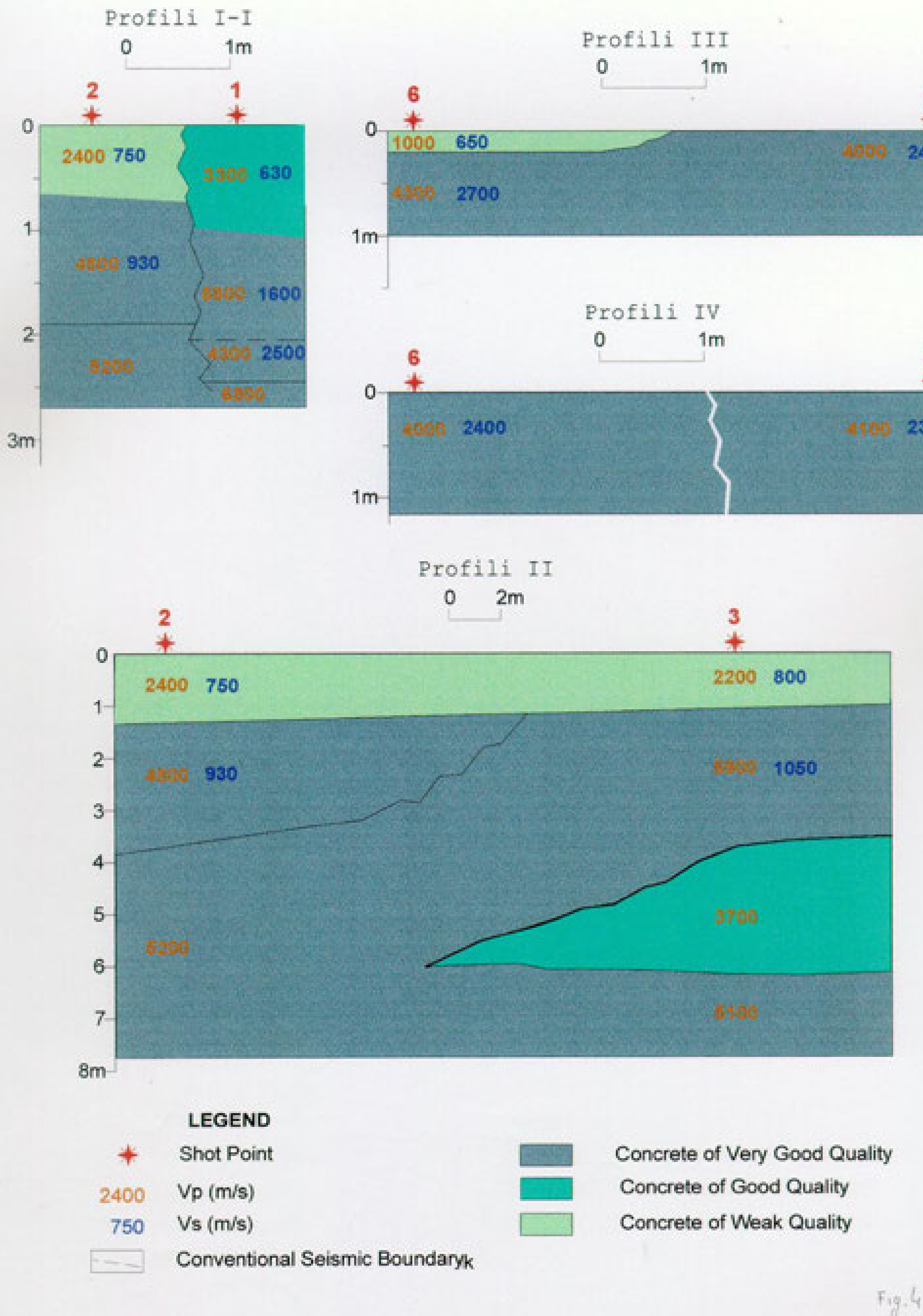
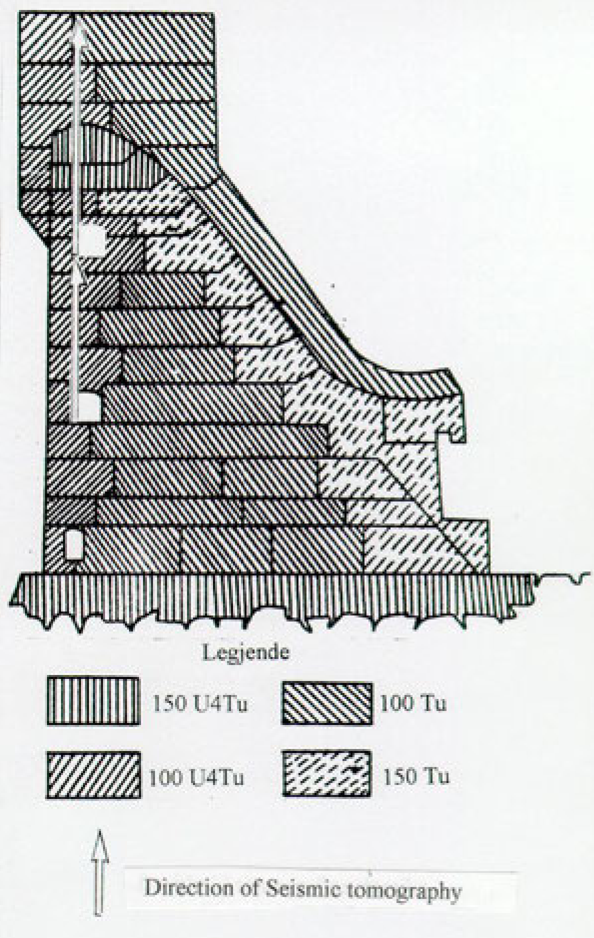

QUALITY OF CONCRETE IN GALERIES ACCORIDNG TO SEISMIC INVESTIGATION
2 METERS UNDER GALERY FLOOR, CONCRETE SECTION OF QYRSAQ DAM,
HYDROELECTRICAL POWER PLANT OF VAU DEJES
June, 1996
0 2 4 6 8 10m
4800
930
2
Gal. 30
5900
1000
3
1
5800
2000
Gal. V30
4300
2700
6
Gal. VE. 42
4000
2400
5
7
4300
2400
Gal.42 Ver.
4100
2300
4
LEGEND
Shot Point
4100 Vp (m/s)
2300 Vs (m/s)
Concrete of Very Good Quality

Fig. 2


QUALITY OF CONCRETE IN GALERIES ACCORIDNG TO SEISMIC INVESTIGATION
0.5 METERS UNDER GALERY FLOOR, CONCRETE SECTION OF QYRSAQ DAM,
HYDROELECTRICAL POWER PLANT OF VAU DEJES
June, 1996
0 2 4 6 8 10m
2400
750
Gal. 30
2
1
5800
2000
2200
800
3
1000
650
6
Gal. VE. 42
4000
2400
5
7
2800
1400
Gal. V30
Gal.42 Ver.
4
LEGEND
Shot Point
2800 Vp (m/s)
1400 Vs (m/s)
Concrete of Very Good Quality
Concrete of Good Quality
Concrete of Weak Quality
Fig.3

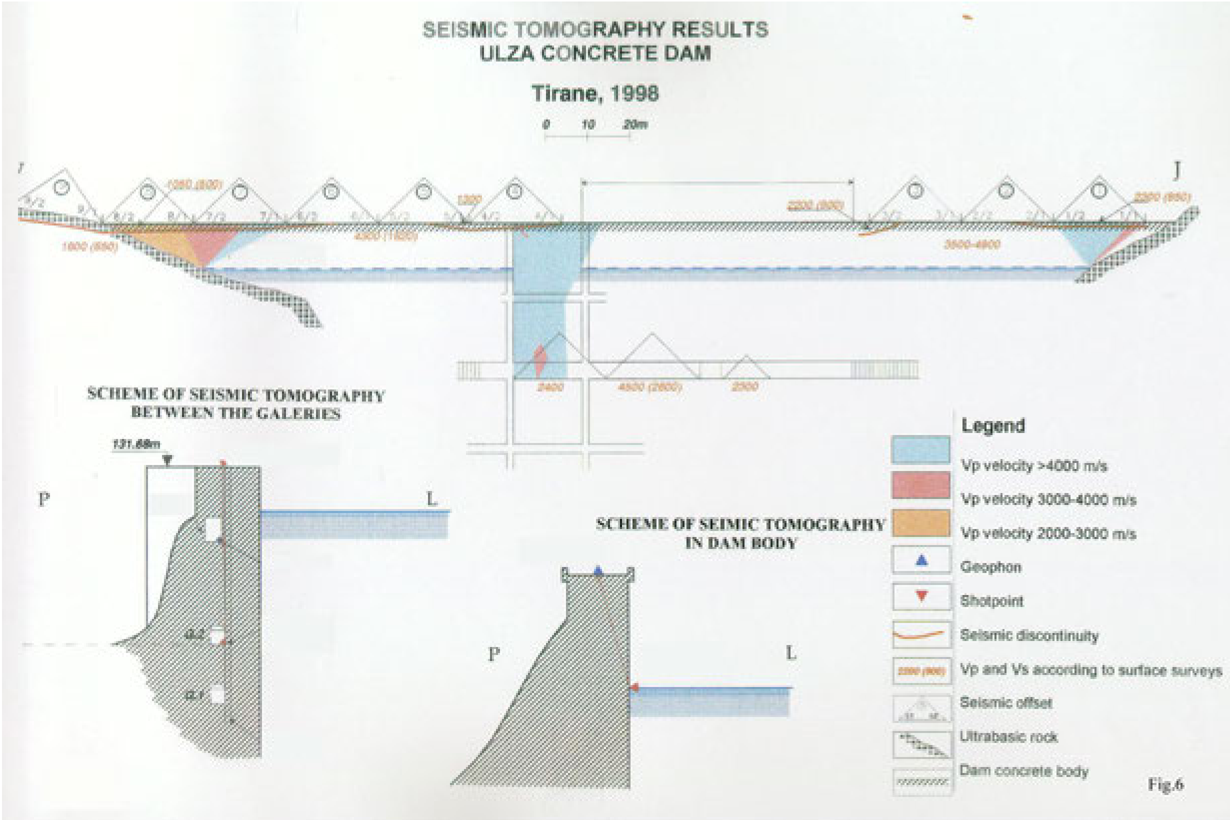
SEISMIC SECTION
HYDROELECTRIC POWER PLANT OF VAU DEJES
CONCRETE SECTION OF QYRSAQ DAM
December 1997

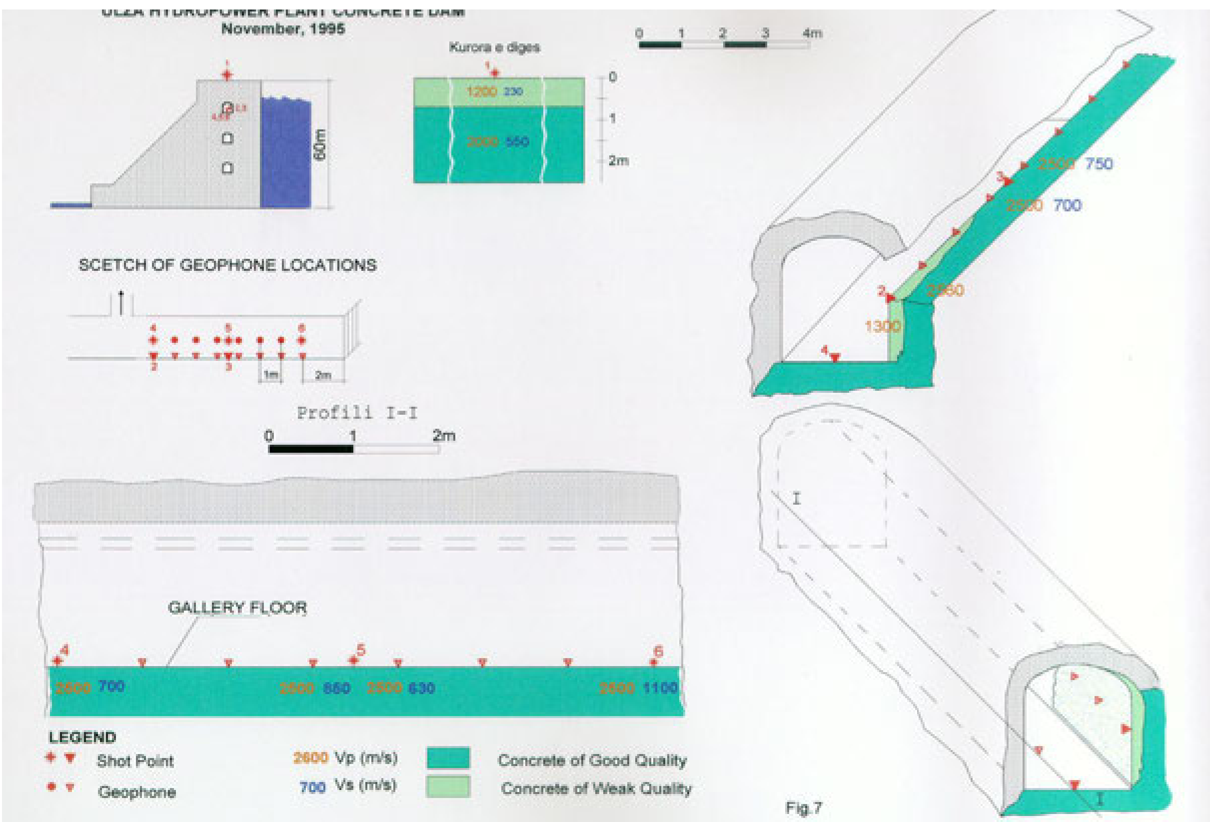




CONCRETE BLOCKS WITH DIFFERENT QUALITY OF ULZA DAM

Fig.5


SEISMIC TOMOGRAPHY RESULTS
ULZA CONCRETE DAM
Tirane, 1998
SCHEME OF SEISMIC TOMOGRAPHY BETWEEN THE GALERIES
SCHEME OF SEIMIC TOMOGRAPHY IN DAM BODY
Legend
Vp velocity >4000 m/s
Vp velocity 3000-4000 m/s
Vp velocity 2000-3000 m/s
Geophon
Shotpoint
Seismic discontinuity
Vp and Vs according to surface surveys
Seismic offset
Ultrabasic rock
Dam concrete body
Fig.6


November, 1995
Kurora e diges
SCETCH OF GEOPHONE LOCATIONS
Profili I-I
GALLERY FLOOR
LEGEND
Shot Point
Geophone
2600 Vp (m/s)
700 Vs (m/s)
Concrete of Good Quality
Concrete of Weak Quality
Fig.7

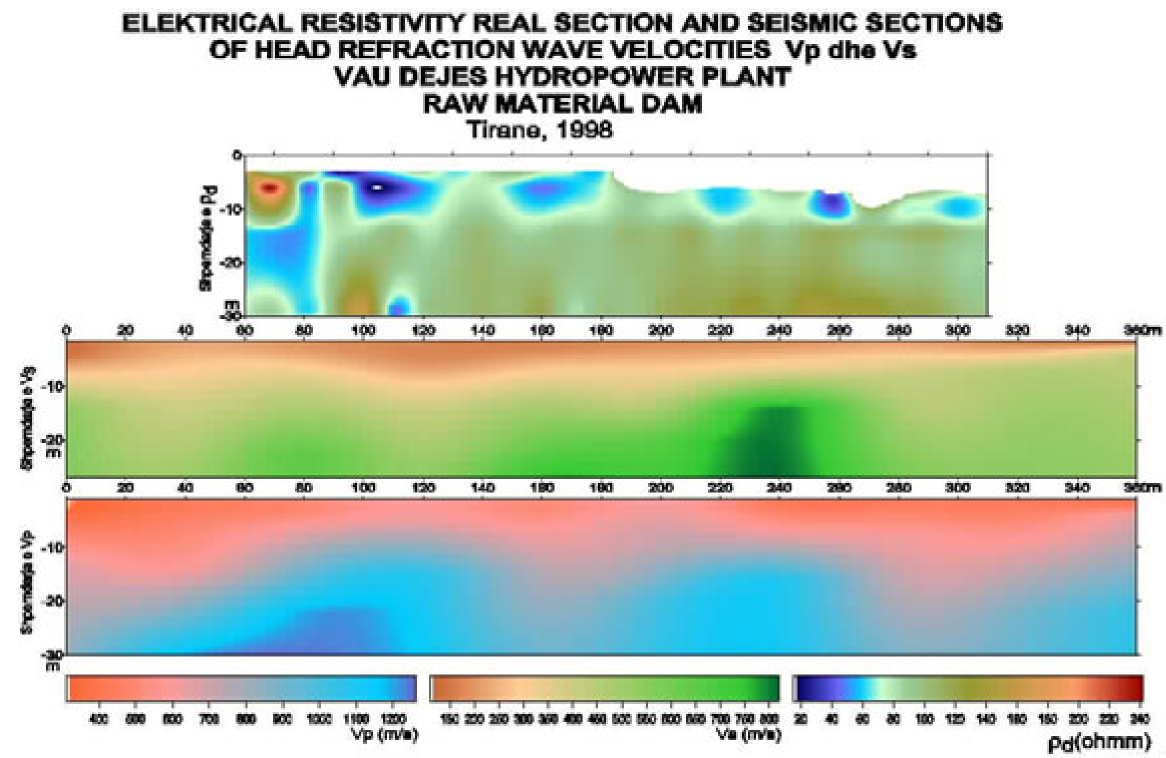
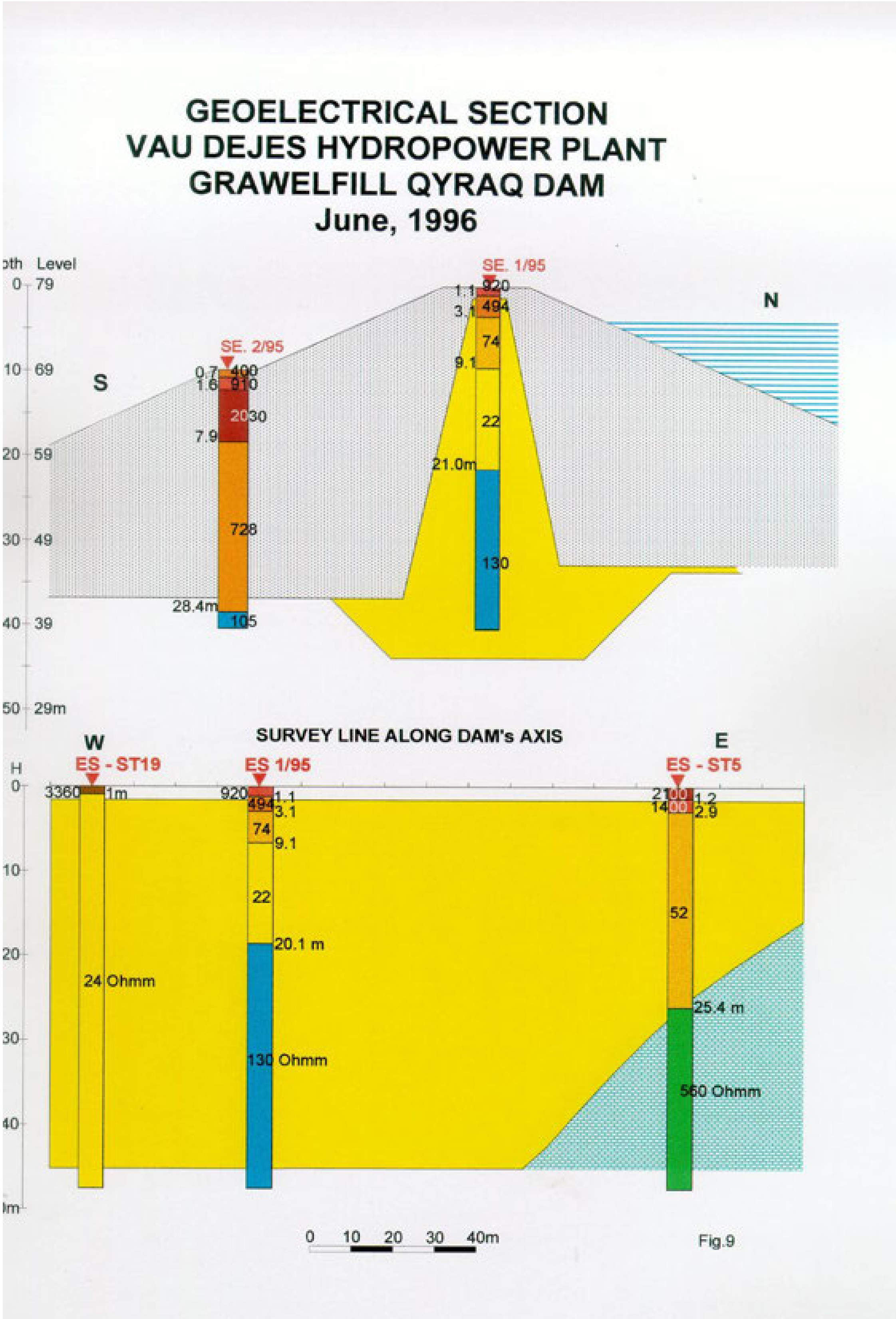

ELEKTRICAL RESISTIVITY REAL SECTION AND SEISMIC SECTIONS
OF HEAD REFRACTION WAVE VELOCITIES Vp dhe Vs
VAU DEJES HYDROPOWER PLANT
RAW MATERIAL DAM
Tirane, 1998
Vp (m/s)
Vs (m/s)
ρd(ohmm)

Fig.8


GEOELECTRICAL SECTION
VAU DEJES HYDROPOWER PLANT
GRAWELFILL QYRAQ DAM
June, 1996
Level
SE. 1/95
SE. 2/95
S
N
28.4m
21.0m
SURVEY LINE ALONG DAM's AXIS
W
E
ES - ST19
ES 1/95
ES - ST5
24 Ohmm
130 Ohmm
560 Ohmm
20.1 m
25.4 m
0 10 20 30 40m
Fig.9

PROCEEDINGS, Twenty-Fifth Workshop on Geothermal Reservoir Engineering
Stanford University, Stanford, California, January 24-26, 2000
SGP-TR-165

THE EXPLOITATION OF WATERS OF GEOTHERMAL WELLS AND SPRINGS IN ALBANIA REPRESENT GREAT IMPORTANCE AND FRUITFUL INVESTMENT

Prof. Dr. Alfred FRASHERI

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GENERAL DATA ABOUT THERMAL AREA IN CENTRAL ALBANIA AND SIGNIFICANCE OF THE PROPOSED INVESTMENT

Two thermal wells and Ishmi-1/b, Kozani-8 and thermal springs of Llixha-Elbasani SPA in central region of Albania and of Kruja geothermal area have a self-discharge of hot and mineralized water (Fig. 1) (Frasheri A. et al. 1995, 1995, 1996).

Kruja geothermal area start on the Adriatic coast, Northern of Durresi city, in Ishmi region, continues in Tirana, in Elbasani up to South-Eastern Albanian-Greek border and extends to the Konica district in Greece.

Heat Flow Density in Albanian territory has its highest value of 42 mWm^{-2} in the center of the Peri-Adriatic Depression, in western part of country. Thirty $mW.m^{-2}$ contours stay open towards the Adriatic Sea shelf, where the epicenter of the anomaly is situate with a Heat Flow Density up to 100 mWm^{-2}, discovered by Italian geothermists (Geothermal Atlas of Europe). In the salt diapir of Dumrea, near of Elbasani in western direction, Heat Flow Density value is 37 mWm^{-2}. The contours of Heat Flow Density with maximal values up to 60 mWm^{-2} give a clear configuration of ophiolitic belt in eastern regions of Albania.

In the Ishmi area, the **Ishmi-1/b well** is the northernmost well of the Kruja geothermal area. It is located in the upper part of the fissured and karstified limestone structure. It is 20 kilometers NW of Tirana (near of Rinasi-Tirana Airport), in the flat area. It enters limestone section at 1300 meters and continues through carbonatic strata of more than 1000 meters in thickness. Ishmi carbonatic section is characterized by relatively low apparent electrical resistivity, varying between 50-200 Ohm.m. Such low resistivity zone can be explained as a result of alternating high permeability collectors filled with mineralized water with low permeability limestone layers. These former are of 5-10 meters in thickness, having an effective porosity of $(5.8\text{-}7)\cdot 10^{-3}$, with a permeability of 0.05-3.5 mDarcy. Limestone shown hydraulic conductivity of $8.6\cdot \times 10^{-10}$- $8.8\cdot\times 10^{-8}$ m/sec and the transmisivity of 8.6×10^{-7} to 8.5×10^{-5} $m^2.sec^{-1}$ (Frasheri et al., 1996, Doracaj M. 1986). There are a primitive small SPA.

Kozani-8 well is located 35 kilometers southeast of Tirana, on hills only 2 km from the Tirana-Elbasani national road. It enters limestone strata at 1819 meters of depth and penetrates 10 meters deeper. Thermal water of this well discharged unused in the river during a ten years period.

In the Kruja geothermal area there are **thermal springs of Llixha Elbasani SPA**. It is located about 12 kilometers south of Elbasani. There are seven groups of springs that extend in a belt of the 320° azimuth. All of them are connected to a main regional thrust tectonics of the Kruja zone. Thermal waters flow out through the contact of conglomerate layer with calcolistolith. In this area too, the reservoir is represented by the Llixha limestone structure (Frasheri et al., 1996, Çela, 1991).

Surface water temperatures in the Tirana-Elbasani zone vary from 60°C to 65.5°C. At the depth on the top of the aquifer in the Kozani-8 hole the temperature of water is 80°C. According to the temperature log in Ishmi-1/b measured prior to water outflow started, temperatures of the carbonatic section were 42.2°C. The difference between the temperatures of thermal water and limestone section shows that a mixture of waters has occurred: water of the reservoir mixed with thermal water which comes from the greater depth.

Aquifer temperature for Elbasani Llixha springs varies form 143° to 254° and 235°C, respectively according the calculations carried by Na+K+Ca, Fournier and Truesdell formulas.

Elbasani Llixha springs, and since the end of the drilling operation of Ishmi-1/b and Kozani-8 wells (in 1964, and/or 1988 respectively.) Hot water has continued to fountain and have constant yields for THESE long periods of time, from 3.5 to 15 l/sec for 50 years and/or 10 years, respectively.

Water temperature is stable. Hot water is mineralized, with a general mineralization of 4.6-19.3 g/l. Elbasani Llixha water has the following formula (Avgustinsky et al., 1957):

$$H_2S_{0.403}M_{7.1}\frac{Cl_{59}\times SO_{38}^{4}}{Na_{46}\times Ca_{35}}$$

In Tirana-Elbasani area, thermal waters are of chlor-magnesium type. They contain cations Ca^{++}, Mg^{++}, Na^{+} and K^{+}, as well as anions Cl^{-}, $SO4^{--}$, HCO_3^{-} etc. with pH=6.7-8 and density 1.001 to 1.006 g/cm^3.

For the Tirana-Elbasani subzone heat in place is 5.87 x·10^9- 5.08·x 10^{10} GJ, identified resources are 5.87·x 10^8-5.08·x 10^9 GJ, while specific reserves gave values of 38.5-39.6 GJ/m^2.

Elbasani Llixha SPA is located about 10 km south of Elbasani City and 61 km in southeast of Tirana, in the Central part of Albania. By national road communication, Llixha area is connected with Elbasani and Tirana. Only 10 km will be from the highway Durresi- Skopje- Sofia- Istanbul, which is projected for construction in the future and nominated as No. 8 European Corridor. The proximity with highways creates great possibilities for Elbasani Llixha SPA to be a nice place. This area may be frequented by a large number of people from different Balkan countries, Italy, UK, Germany, Ostrich, France, Low Countries, and by Albanians from Albania, Macedonia and Kosovo as well. These thermal springs from about 2000 years are known years ago. According to historic data, in Elbasani Llixha thermal springs there has been an inn, near of the old road "Via Egnatia" that has passed from Durresi to Constantinople.

There are seven spring groups that extends like a belt with 320^o azimuth. Surface water temperature is about 60^{o}C and yield in total 15 l/sec. Springs have constant hot water yield and temperature for a long period of time. These data are evidence of a stable thermo-hydrodinamic reservoir regime.

Before the Second World War, in one from the springs ("Nosi spring") has been constructed " PARK-NOSI" SPA (***), with 166 beds, for medical treatment of various diseases, generally rheumatic. The "NOSI" SPA functioned during a period of time more than 60 years and for the present is private property. Land with surface of 20 000 m^2, hotel and restaurant are owned by PARK NOSI Sh.p.k. Particularly reconstructed hotel after the privatization actually is in work. Near this property there is located a public hotel, with 180 beds, almost in destruction state, but which may be reconstruct.

About 330 Albanian patients in year treated (during two weeks period) for rheumatism and various illnesses in two hotels of the Elbasani Llixha SPA

Actually, there is not a law for thermal waters in Albania. The PARK NOSI Sh.p.k. Llixha Elbasani and SPA is used thermal water as ex-owner of SPA before the Second World War. SPA in Ishmi well area has privates in 1993.

All seven groups of the springs in Llixha Elbasani and Kozani-8 well geothermal area will have the possibilities for modern complex exploitation and cascade use of thermal water. The beautiful landscape of Elbasani area will be not only for medical treatment but also as tourist place. This area located near of the very know Ohrid Lake pearl or mountains Gjinari, with their fantastic forests and nice climate.

In conclusion, reservoir is a heterogeneous collector and its thermo-hydrodynamic regime is stable in Kruja geothermal area. In this geothermal zone could find other springs with greater geothermal resources, higher yield and water temperature. For that, it is necessary that hydrogeological and geophysical investigations must carry out and new wells must drilled, in order to capture the water deeper where the temperature is higher.

OBJECTIVES OF THE PROJECT PROPOSAL

Integrated exploitation and cascade direct use of the geothermal energy has projected.

The objectives of the project:

2.1. The detailed feasibility study of the geothermal and mineral water resources in Kozani-8 and Ishmi-1/b wells, and in Elbasani Llixha SPA. General project idea and particularly, technical designs will be compiled for new investment

2.2. Modern unit of equipment for the thermal water in the wells, and in Llixha Elbasani springs will be installed.

2.3. Clinic SPA in the Saint Joan Monastery, heating of the existing buildings of the Monastery and greenhouse for the flower projected to construct, for the integrated and cascade use of thermal water of Kozani-8 well, located 1.3 km from the Monastery.

Reconstruction of the PARK Hotel or Ishmi SPA heating system and thermal baths will help to create normal condition for all the year SPA frequenting.

2.4. Green house will be constructed for flowers, for sale in Albania and for export. The green house will be used particularly for legumes, to provide the restaurant of the SPA.

2.5. Construction of new modern hotel of (****), with thermal water and mud baths, thermal swimming pool, clinic, halls for the massage and physical rehabilitation, restaurant and bar. In the beginning, this hotel may be design for 30-40 beds. In the perspective, in the hotel will be built new floors, for a total of 80-100 beds. This hotel will serve for foreign and rich Albanian patients.

2.6. An aquaculture installation has projected.

2.7. Unit equipment for thermal water treatment will be constructed, before their outflow. Construction of unit equipment for chemical microelements, different natural salts extraction. These salts are very valuable to prepare the pomades for skin diseases medical treatment and beauty creams. The unit will be used also for CO_2 and H_2S free gas extraction. H_2S gas is very valuable for the special treatment of the respiratory apparatus. This process will protect the area echo-system.

2.7. A promotion and tourist agency will be organized. This agency will prepare the reclaims and booking of the rooms for Albanian and foreign patients.

WORK PROGRAMME

This project will be implemented during the 3 years period, by the integration of the following four Phases:

First Phase

1. Geothermal and mineral water resources detailed feasibility study will be carried out for Kozani, Ishmi and Elbasani Llixha area. Project idea will be compiled, too.
2. Technical projects will be compiled for investments in Kozani-8, Ishmi wells or in PARK NOSI SPA.

6 months

Second Phase

1. Construction of thermal water unit equipment in Kozani-8 well, in Llixha Elbasani springs or Ishmi well.
2. Heating system, the thermal water unit equipment and baths will be reconstructed in PARK Hotel of Ishmi SPA. After second phase, all year SPA frequenting will realize. During the winter there are more demands for the medical treatment.

Good conditions in the SPA will help to have patient numbers increasing. Two green house, up to 3000 m^2 surface, will be constructed in the territory of Kozani-8, and in Ishmi 1/b wells or in PARK NOSI Sh.p.k.

6 months

Third Phase

Clinic SPA in the Saint Joan Vladimir Monastery and new hotel construction of (****) in Kozani, Ishmi or Llixha Elbasani area. For the first time, the SPA Clinic and the hotel will have two or three floors, with the possibilities to build and 2 or three other floors in the future. In the ground floor will be located the restaurant, bar, medical clinic and thermal baths. Bedrooms will be located in the first and second floors. Thermal swimming pool will construct in the ground floor or in the yard.

24 months

Fourth Phase

1. Unit equipment for the extraction of chemical microelements and salts, CO_2 and H_2S gas will be designed and installed.
2. Unit equipment and collector for treatment and clearing the thermal water before their outflow will be designed and installed, to protect echo-system of the area.
3. Promotion and tourist agency will be organized. Put in full efficiency of all complex of the SPA will be completed.

10 months

PRELIMINARY COST FOR THE INVESTMENT FOR PHASES I-III

Cost estimation is carried out only for the three first phases, to realize investment step by step:

No	Object	Cost, in USD
1	Reconstruction of heating and thermal baths	50 000
2	Construction of two thermal water unit equipment's	80 000
3	Construction of green houses, 2 * surface 3 000 m^2	240 000
4	Construction of SPA Clinic in Saint Joan Vladimir Monastery and for new hotel (building), (****)	5 000 000
5	Feasibility study and project idea	53 000
6	Technical projects	100 000
7	Travel and subsistence	20 000
8	External Assistance	20 000
9	Other Expenditures	20 000
10	Overhead rate	15 000
	TOTAL exc. VAT	5 968 000

Well come to investment in geothermal areas in Albania for the integrated and cascade direct use of geothermal energy.

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Fig.1 Ishmi 1/b - Kozani 8 - Llixha Elbasan Geothermal Area

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Sherbimi Gjeologjik i Shqiperise.

SINJALET E TEMPERATURES NGA THELLESIA E ALBANIDEVE

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Hyrje

Vitet 90 ka qenë periudha e studimeve gjeotermale në Shqipëri, në kuadrin e te Atlasit Gjetermal të Shqipërisë, të Atlasit Gjeotermal të Evropës, dhe të Atlasit Evropian të Burimeve të Energjisë Gjeotermale. Krahas matejve termike të reja janë përgjithësuar edhe rezultatet e matjeve termike në puset e naftës e të gazit, të kryera nga viti 1952 deri me sot (1, 2, 3, 4).

Në këtë artikull po paraqesim rezultatet e modelimit mathematikor gjeotermik në profilet Albanid-1 (Falco-Durrës-Tiranë-Peshopi) dhe Albanid-2 (Falco-Seman-Bilisht), të cilët kanë dhënë tablonë e shpërndarjes së temperaturës deri në thellësitë rreth 50 km. Këto modelime shërbyen edhe për plotësimin e interpretimit të hartës së Dendesisë së Fluksit të Nxehtësisë të Shqipërisë.

Parashtrimi i problemit

Modelimi gjeotermik u realizua mbi bazën e rezultateve të vrojtimeve gjeotermike të kryera në Shqipëri, me anën e metodës së elementeve të fundme. Për këtë u shfrytëzuan hartat e temperaturave në thellësitë 100 m, 500 m, 1000 m, 2000 m dhe 3000 m, harta e gradientit mesatar, harta e dendësisë së fluksit të nxehtësisë (Fig.1), Harta Gjeologjike e Shqipërisë në shkallë 1:200.000, si edhe rezultatet e përcaktimeve të vetive termike të shkëmbinjve, Modelet gjeotermike u ndërtuan mbi bazën e profileve gjeologo-gjeofizike krahinore Albanid-1 dhe Albanid-2 (3). Rezultatet e modelimit janë paraqitur në fig. 4, 5, 6.

Analizë dhe diskutim

Analiza e shpërndarjes së temperaturave deri në thellësinë 50 km në profilet Albanid-1 dhe Albanid-2 tregon se gradienti gjeotermik ndryshon si përgjatë profileve ashtu edhe në thellësi. Në Ultësirën Pranadriatike gradienti gjeotermik mbetet i pandryshuar deri në thellësinë rreth 20 000 m, afërsisht deri në tavanin e bazamentit kristalin. Vlera e këtij gradienti luhatet nga 15-21.3 mK/m. Më thellë ai zvogëlohet. Tablo e njëjtë e gradientit gjeotermik është edhe deri në kufirin lindor të zonës tektonike Mirdita. Por në këtë zonë gradienti arrin vlerën 36 mK/m, që është gati dy herë më e madhe sesa në Ultësirën Panasriatike. Ai mbetet konstant deri në thellësinë rreth 12 000 m; më thellë zvogëlohet. Kjo thellësi përkon me tavanin e kriprave triasike (fig. 3). Në të dy profilet vërehet tablo e njëjtë e temperaturave më të mëdha në zonën Mirdita, sesa në Albanidet e Jashtme, për të njëjtën thellësi.

Duke analizuar hartën e dendësisë së fluksit të nxehtësisë (fig. 1), spikatin dy karaktere të tablosë së këtij fluksi në Albanidet:

Së pari, në Albanidet e Jashtme dendësia maksimale e fluksit të nxehtësisë arrin deri 42 mW/m^2, ndërsa në pjesën lindore të Albanideve të Brendëshme arrin deri 60 mW/m^2. Izolinjat e dendësisë së fluksit të nxehtësisë shkojnë në pajtim me kufirin e brezit ofiolitik.

Duke qenë se brezi ofiolitik është ndërtuar nga shkëmbinj me përmbajtje të papërfillshme të elementëve radioaktivë, është shumë e vogël sasia e nxehtësisë të gjeneruar nga masivët ofiolitikë. Kjo tregon se fluksi i nxehtësisë më i madh në zonën Mirdita i detyrohet nxehtësisë që vjen nga thellësitë. Siç duket në profilin Albanid-1, blloqet e fundamentit kristalin janë vendosur më cekët në zonën Mirdita. Nga granitet e këtij fundamenti, siç dihet, gjenerohet shumë nxehtësi nga zbërthimi i elemntëve radioaktivë, që ata përmbajnë. Në këtë drejtim zvogëlohet edhe trashësia e kores së Tokës dhe kufiri MOHO është më i cekët. Prof. Dr. Teki Biçoku mendon se edhe përmbajtja e kaliumit 40 në evaporitet e thellësisë mund të jetë një nga burimet e gjenerimit të nxehtësisë në këtë zonë, me të cilin pajtohet edhe autori i artikullit. Dhe nëse qëndron ky supozim, atëhere rrjedh se nën zonën Mirdita, depozitimet lkripore duhet të kenë trashvsi të madhe.

Së dyti, në zonën e Runës në masivin ultrabazik të Kukësit dhe në Rehovë të Korçës, fluksi i nxehtësisë arrin vlerat maksimale. Këto vatra mund të jenë shkaktuar nga transmetimi më intensiv i nxehtësisë nëpër thyerjet e thella, qoftë edhe ato tërthore. Me këto thyerje lidhen edhe burimet e energjisë gjeotermale në Albanidet. Sipas gjeotermometrave kemi llogaritur se ujrat termalë kanë temperaturë 220-270 ^{o}C në rezervuarin parësor ku janë formuar. Këto temperatura gjenden në thellësitë 12-15 km.

Përfundime

1. Shpërndarja e fluksit të nxehtësisë në Albanidet dëshmon për karakter bllokor të fundamentit kristalin. Thellësia e vendosjes së ketyre blloqeve është më e vogël në zonën Mirdita sesa në Albanidet e Jashtme.
2. Anomalitë lokale të fluksit të nxehtësisë në masivin ultrabazik të Kukësit dhe në Rehovën e Korçës dëshmojnë për ekzistencën e thyrjeve të thella tërthore, nëpër të cilat është relativisht më i mëdh fluksi i nxehtësisë.
3. Me fluksin e nxehtësisë më të madh në thyerjet e thella lidhen edhe burimet termale.

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Lista e figurave

Abstract

In the paper are presented the result of the geothermal modeling in Albanid-1 and Albanid-2 lines. These modeling are part of geothermal studies in Albania during the 90 years, in the framework of Geothermal Atlas of the Albania, European Geothermal Atlas and European Geothermal Resources Energy Atlas (1, 2, 3, and 4).

Geothermal gradient changes from western to the eastern part of the Albania, and in the depth, too. The gradient values vary from 15-21.3 mK/m in Pre-Adriatic Depression. According to the modeling results, deeper than 20 km are observed decreasing of the gradient. This change of the gradient is coincided with the top of the crystal basement. In the ophiolitic belt of the Inner Albanides, the geothermal gradient has a value up to 36 mK/m at northeaster and southeastern part of the Albania. Decreasing of the gradient are observed deeper than 12 000 meters in this side of Albania, at the top of the Triassic salts deposits (fig. 3). In the both lines are observed that the temperatures in ophiolitic belt are higher than in the sedimentary basin, at the same depth.

In the Heat Flow Density Map of Albania (fig. 1), is possible to observed two particularities of the scattering of the thermal field of the Albanides:

Firstly, 42 mW/m^2 is maximal value of the heat flow in the External Albanides. At the eastern part of Albania, the heat flow density values are up to 60 mW/m^2. Radiogene heat generation of the ophiolites is very low. In these conditions, increasing of the heat flow in the ophiolitic belt, are linked with heat flow from the depth. According to the Alb-1 line, the granites of the crystal basement, which have the possibilities for the great radiogenic heat generation represents the heat source. In ophiolitic belt, is observed decreasing of the MOHO discoinity depth.

Secondly, in the ophiolitic belt are observed some hearth of higher heat flow density. Heat flow anomalies are conditioned by intensive heat transmitting through deep and transversal fractures. These fractures are conditioned location of the geothermal energy sources. According to the calculation of different geothermometers, the aquifer estimated temperatures are 144 to 270^{o}C. Based on the geothermal modeling, one can suppose that thermal waters rises from 8-12 km deep, where temperature attains to 220^{o}C.

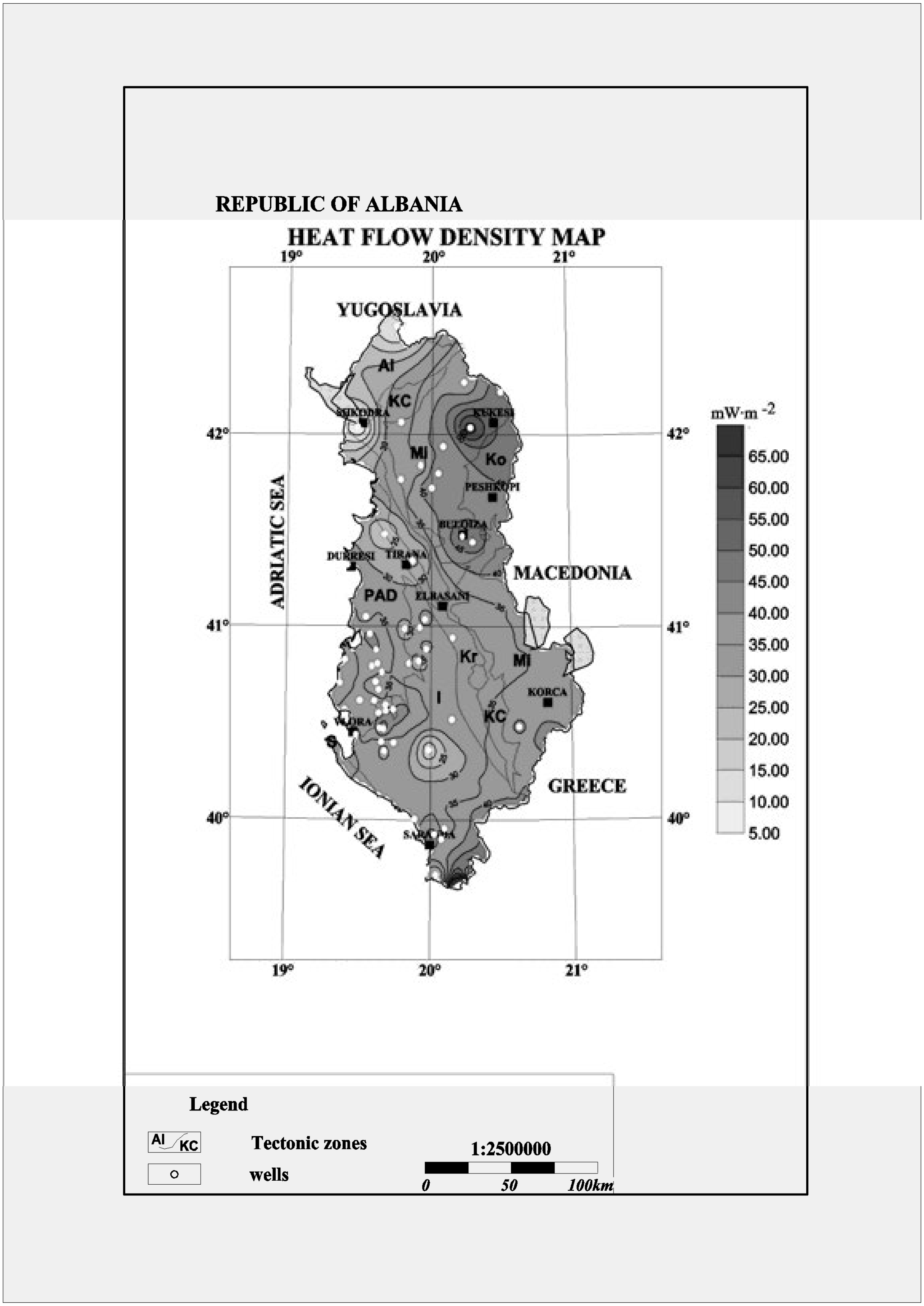


Fig. 1. Harta e Dendësisë së Fluksit të Nxehtësisë së Shqipërisë

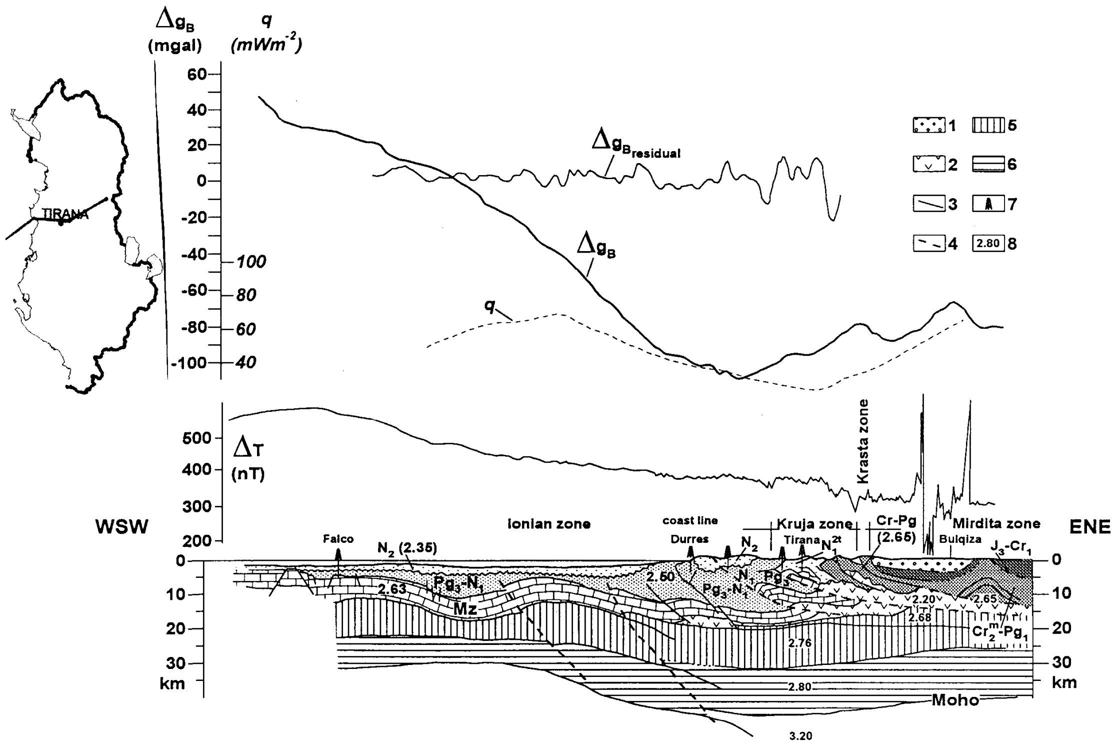


FIG. 2. Geological-geophysical transect ALB-1 through north-central Albania. For location see Fig. 1.
N-Neogene, Pg-Paleogene, Cr-Cretaceous, J-Jurassic, MZ-Mesozoic.
1) ultrabasic rocks, 2) salt, 3) faults, 4) crustal fractures, 5) upper crust, 6) lower crust, 7) upper mantle, 8) deep wells, 9) density g/cm^3.

Fig. 2. Profili gjeologo-gjeofizik Albanid-1, Falco-Durrës-Tiranë-Peshkopi

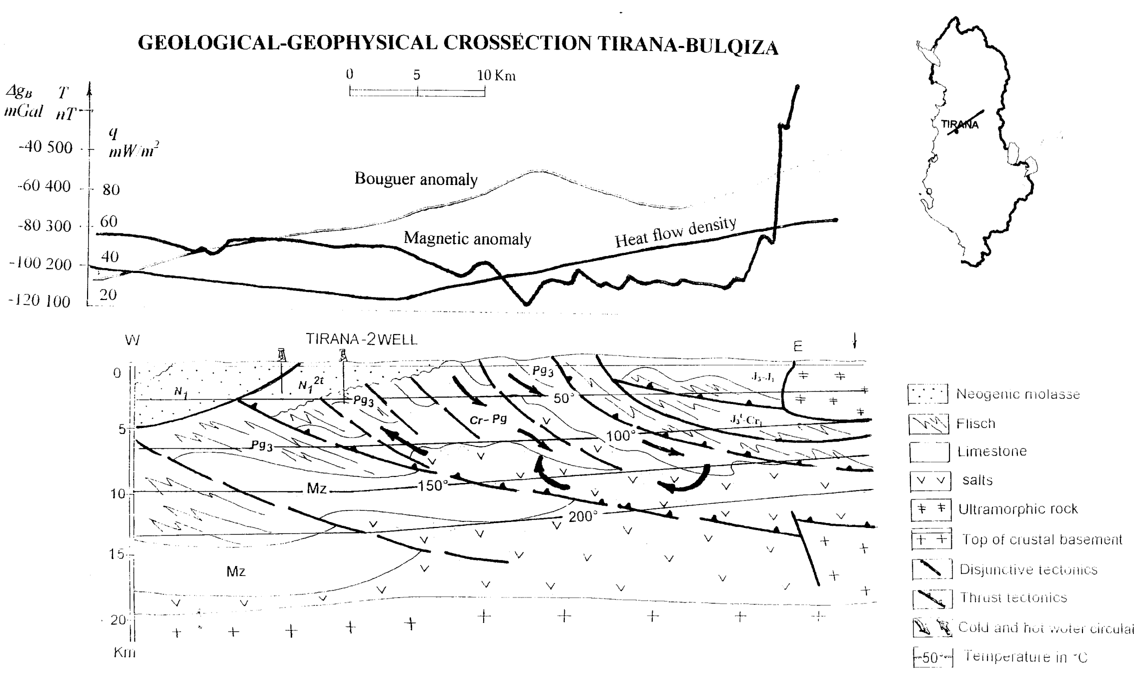


Fig. 3. Profili gjeologo-gjeofizik Tiranë-Bulqizë

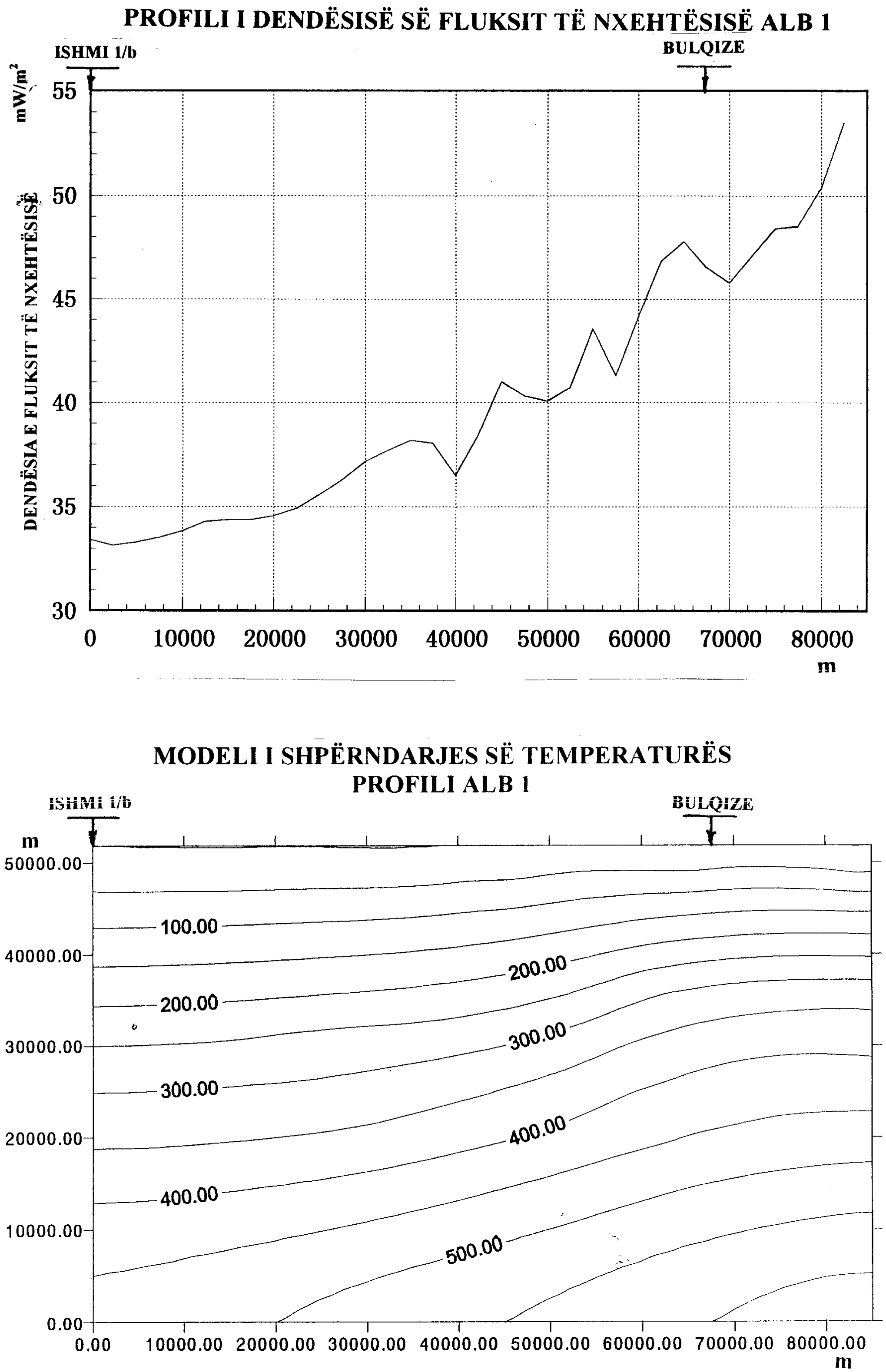


Fig. 4. Rezultatet e modelimit gjeotermal në profilin Albanid-1

Fig. 23 - Geological-geophysical profile Albanides.

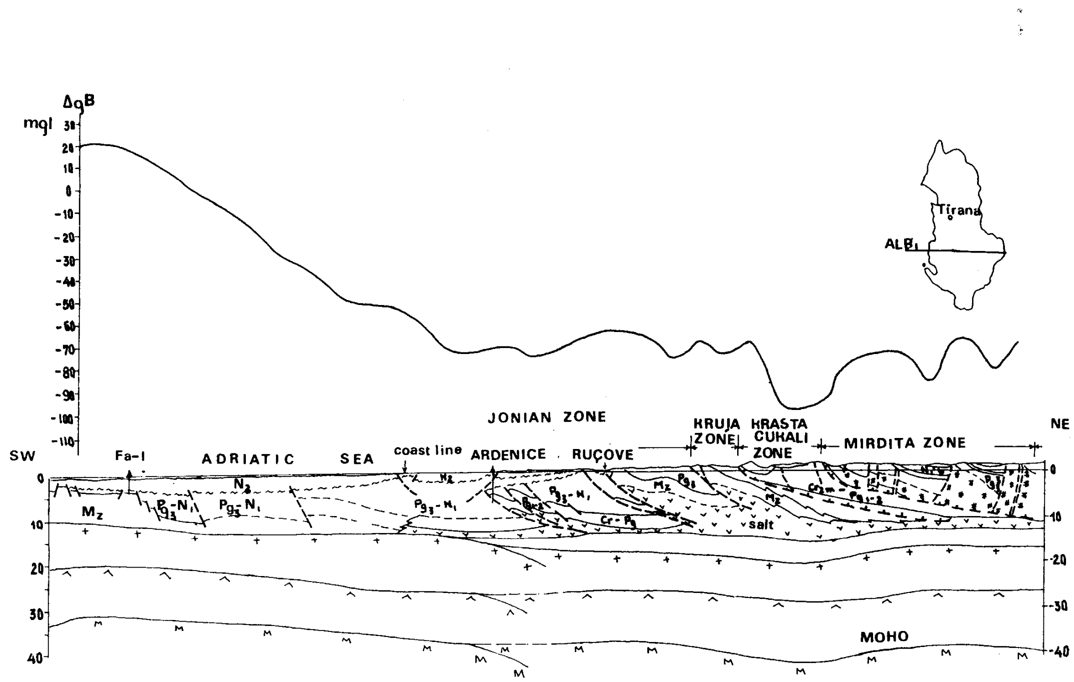
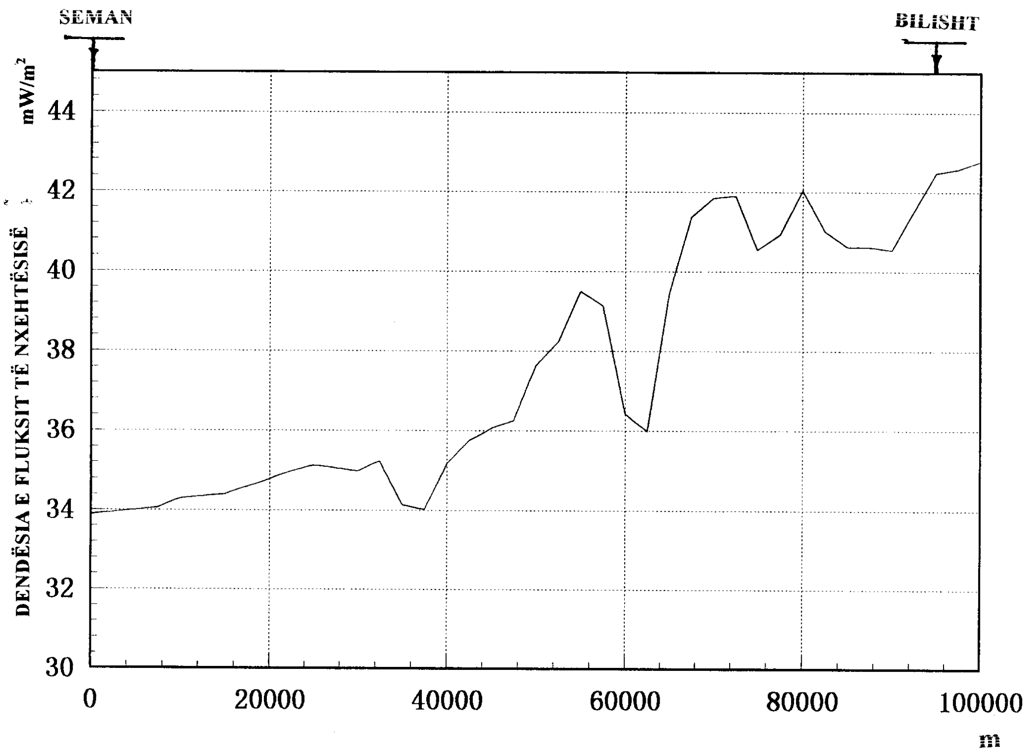


Fig. 5 Profili gjeologo-gjeofizik Albanid-2, Falco-Seman-Bilisht

PROFILI I DENDËSISË SË FLUKSIT TË NXEHTËSISË ALB 2



MODELI I SHPËRNDARJES SË TEMPERATURËS
PROFILI ALB 2

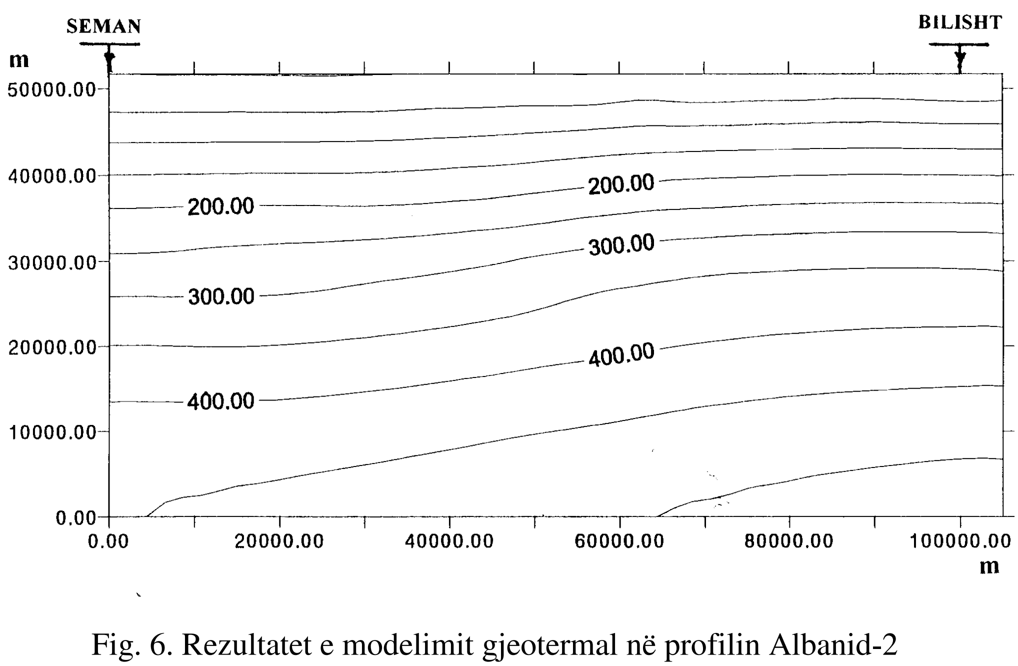


Fig. 6. Rezultatet e modelimit gjeotermal në profilin Albanid-2

THE SOURCES OF GEOTHERMAL ENERGY IN ALBANIA

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Keywords: Albania, heat flow, thermal springs, thermal wells, thermal area, thermal resources.

ABSTRACT

The results of geothermal investigations in Albania are treated in this article. The aim of this paper is to present the possibilities for the extension of energy resources in Albania through the use of geothermal energy. Geothermal investigations in the past three years have shown that possibilities for the exploitation of the geothermal energy exist in Albania. The ways of exploitation of this kind of energy are also given.

1. INTRODUCTION

Albania is a mountainous Mediterranean country with numerous natural energy resources. There are many rivers flowing from the mountains where seven hydro-power plants have been built, with an installed power of 1427.1 MW (Frasheri N., 1994) There are about 20 oil and gas reservoirs under exploitation in Albania, producing about 1.2 Mt oil (Albanian Encyclopedic Dictionary, 1985); but within the last years, the production has decreased, and in 1999 only about 340 Kt of oil were extracted. There are tens of coal mines in Albania, with an output of over 2 Mt coal in 1984 and 214.6 Kt of coal in 1993.

The Albanian energy system is mainly based on electricity produced by hydropower plants. The climate of Albania is a typical Mediterranean one, with a hot and dry summer. This climate can periodically prevent the hydroelectrical system from producing power at capacity (based on the water resources of Albania).

In the present conditions of a new Albanian market economy, together with the transformations in the management of existing energy system, the study of other energy sources has begun. There are great possibilities to use other sources of energy, such as solar (about 129.3 $Kcal \cdot cm^{-2} \cdot year^{-1}$). In the coastal areas the average wind speed is about 2.8-3.8 $m \cdot sec^{-1}$ (Climate of Albania, 1978). There are many regions where the wind speed is several times greater than that in the above-mentioned regions. This is another important source of energy.

In Albania, there are also many thermal water springs and wells of low enthalpy with a temperature of up to 65.5°C, which indicates that it is possible to make use of the geothermal energy.

2. GEOLOGICAL FEATURES

The Albanides form an integral part of the southern branch of the Mediterranean Alpine orogen. They are subdivided into two zones: the Internal and the External Albanides. The Internides are formed by the Mirdita ophiolite nappe, which is separate from the oceanic Subpelagonian Trough (Geological Map of Albania, scale 1:200,000, 1984) Geological and geophysical studies carried out in the External Albanides and in the Adriatic Sea display distinct structural belts, which are related to different tectono-stratigraphic units. From East to West the External Albanides consist of the Krasta-Cukali isopic zone, the Kruja zone, the Ionian zone and the Sazani zone. The Albanian Alps zone is located in northern Albania.

A 1500m thick sequence of Cretaceous to Paleogene neritic carbonates and 5km of Oligocene flysch characterizes the Kruja zone. Locally, a Tortonian continental sandstone facies lies unconformably on a variety of older strata.

The Ionian zone is made up of a thin-skinned fold and thrust belt which is detached from the basement at the level of Permo-Triasic evaporites. Late Triassic and Early Jurassic neritic limestone and dolomites contain cherts. Oligocene and Aquitanian series are developed into flysch and flyschoid facies.

At the base of Burdigalian to Serravalian series, in the clay-marl series of present molassic facies, an angular unconformity is developed.

The Preadriatic Depression is filled with continental and deltaic Miocene and Pliocene series. Serravalian sandstones and clay lie unconformably on deformed older strata and are themselves involved in compressional structures.

Generally, carbonate rocks are fissured and karstified, thus forming important groundwater reservoirs (Dakoli, H., et al. 1981, Hydrogeological Map of Albania, scale 1:200,000, 1985, Eftimi R. et al., 1989).

In the western part of Albania, there are two artesian basins: the Adriatic and Tirana basins. The sandstone aquifers of the Tortonian deposits generally have a low permeability (the medium specific yield of the wells is about 0.04-1 $l \cdot s^{-1} \cdot m^{-1}$.

3. METHODS AND STUDY AREA

Geothermal studies carried out in Albania are oriented toward the study of the distribution of the geothermal fields and the natural thermal water springs and wells. The temperatures have been measured and the geothermal gradient and the heat flow density at different depths have also been calculated (Frasheri et al. 1995). Temperature measurements were

carried out in 145 deep wells, in boreholes, and in mines, at different hypsometric levels.

The temperature in the wells was recorded at regular intervals. It was measured by means of resistance and thermistor thermometers. The average absolute measurement error was 0.3°C. The measurements were carried out in a steady-state regime of the wells filled with mud or water. The recorded data were processed using the trend analysis of first and second degrees.

The chemical composition of the waters was determined. The output of the springs and wells and their hydrogeology was evaluated.

Geothermal studies were extended all over the territory of Albania. In the western regions, where oil and gas reservoirs are situated, the temperature has been recorded in about 120 wells. In the northeast and southeast regions of Albania, about 25 boreholes have been studied together with eight thermal water springs for which the chemical analyses were also carried out.

4. RESULTS

The results of the geothermal studies are presented in maps using contour lines. Temperature maps have been drawn for different levels of up to 5000m depth. Geothermal gradient maps and heat flow density maps have also been drawn. The natural springs with thermal waters and the geological structures with high water temperature have also been mapped. The water basins with higher average temperature than that of mean ambient in one of the regions have been studied as well.

An investigation has begun into the possibility of exploitation of abandoned deep oil wells as "Vertical Earth Heat Probes" (Frasheri A., Bakalli F., 1995) has already begun.

5. DISCUSSION

The geology of the Albanides defines the regional possibilities for the research and exploitation of natural geothermal energy resources (Frasheri A., et al., 1995. Frasheri A. & Bakalli F., 1995). The greatest heat flow densities are found in the center of the Preadriatic Depression, where the value is 42 $mW \cdot m^{-2}$, and in the east of the ophiolitic belt, where heat flow density reaches values of up to 60 $mW \cdot m^{-2}$ (Fig. 1).

The temperature varies from a minimum of 12°C at a depth of 100m up to 105.8°C at a depth of 6000m. In the central part of the Preadriatic Depression, there are many deep oil wells where the temperature reaches up to 68°C at a depth of 3000m. The isotherm runs in a direction that fits that of the strike of the Albanides. The configuration of the isotherm is the same down to a depth of 6000m. With increasing depth, the zones of highest temperature align in a direction southeast to northwest, towards the center of the Preadriatic Depression and even further towards the northwestern coast.

The geothermal gradient reaches ~18.7 $mK \cdot m^{-1}$ in the center of the Preadriatic Depression. Elsewhere the gradient is mostly 15 $mK \cdot m^{-1}$ (Fig. 2). In the south of the country the geothermal gradient has low values 11.5-13 $mK \cdot m^{-1}$. The lowest gradient value of 7-11 $Mk \cdot m^{-1}$ is found in the deep synclinal belts. Towards the northeastern and southeastern regions of Albania, over the ophiolitic belt, the geothermal gradient increases, reaching the value of 23.5 $mK \cdot m^{-1}$.

6. GEOTHERMAL AREAS AND RESERVOIRS

In Albania there are many thermal springs and wells of low enthalpy. Their water temperatures reach values of up to 60°C (Fig. 3). Table 1 presents some data on the water temperature for such springs.

These thermal water springs are mainly near zones of regional tectonic fractures. Generally the water circulates through carbonatic rocks of the structures and evaporitic beds at some kilometers of depth. The water of these springs contains salt, absorbed gas and organic matter. They are sulfide: methane, iodine-bromine and sulfate types.

In many deep oil and gas wells, there are thermal water fountain outputs with a temperature that varies from 32 to 65.5°C (table 2). These waters come from different depth levels (800-3000 m) of limestone reservoirs (wells 1, 2, 3, 4) and sandstone reservoirs (wells 5, 6, 7 and 8).

Presently, the thermal waters of the springs 1, 2, 4, and 6 and wells 1, 2, 3 in Albania are used only for health purposes. These waters could be used for heating purposes and greenhouses as well.

7. DIRECTIONS FOR THE EXPLOITATION OF GEOTHERMAL ENERGY IN ALBANIA

The geothermal situation in Albania offers two directions for the exploitation of geothermal energy, which has not been used so far.

- **First,** thermal water springs and wells of low enthalpy
- **Second,** the use of deep doublet abandoned oil and gas wells and single wells for geothermal energy, in the form of a "Vertical Earth Heat Probe". The geothermal gradient of the Albanian Sedimentary Basin has an average value of about 18.7 $mK \cdot m^{-1}$. At 2000m depth the temperature reaches a value of about 48°C. In these single abandoned wells a closed circuit water system can be installed. This "Vertical Earth Heat Probe", by means of water circulation, is coupled with the heat transfer from the surrounding rocks downwards, to be finally recovered in the tubes (Hoffman F., et al., 1993).

8. CONCLUSIONS

In Albania, there are several geothermal energy sources that can be used. Such geothermal energy sources are natural thermal water springs and deep wells with a temperature of up to 65.5°C. Deep abandoned oil wells can be used as "Vertical

Earth Heat Probe". The use of geothermal energy in Albania must start as soon as possible, in the framework of a separate project, after the compilation of the geothermal resource "Atlas of Albania" in February 1996.

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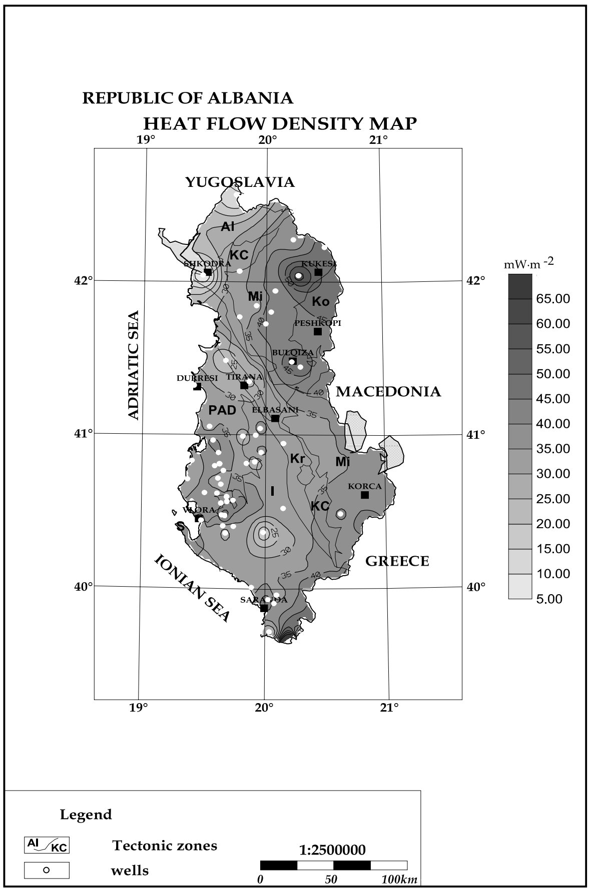
Table 1 THE THERMAL WATER SPRINGS IN ALBANIA

N° of Springs	Location	Temperature in °C	Salt in mg/l	Artesian Spring yield in $l \cdot s^{-1}$
1	Llixha Elbasan	60	0.3	0
2	Peshkopi	5-43	9	10
3	Krane-Sarande	34		<10
4	Langareci-Permet	6-31		>10
5	Shupal-Tirana	29.5		10
6	Sarandoporo-Leskovik	26.7		>10
7	Tervoll-Gramsh	24		>10
8	Mamurras-Tirane	21	26	>10

Table 2: THE OIL AND GAS WELLS THAT HAVE SELF-DISCHARGE OF THERMAL WATER

N°	Well Name	Temperature in °C	Salt in $mg \cdot l^{-1}$	Self-discharge, in $l.sec^{-1}$
1	Kozani-8	65.5	4.6	10.4
2	Ishmi 1/b	64	19.3	4.4
3	Galigati 2	45-50	5.7	0.9
4	Bubullima 5	48-50	35	
5	Ardenica 3	38		15-18
6	Ardenica 12	32		
7	Semani1	35		5
8	Verbasi 2	29.3		1-3



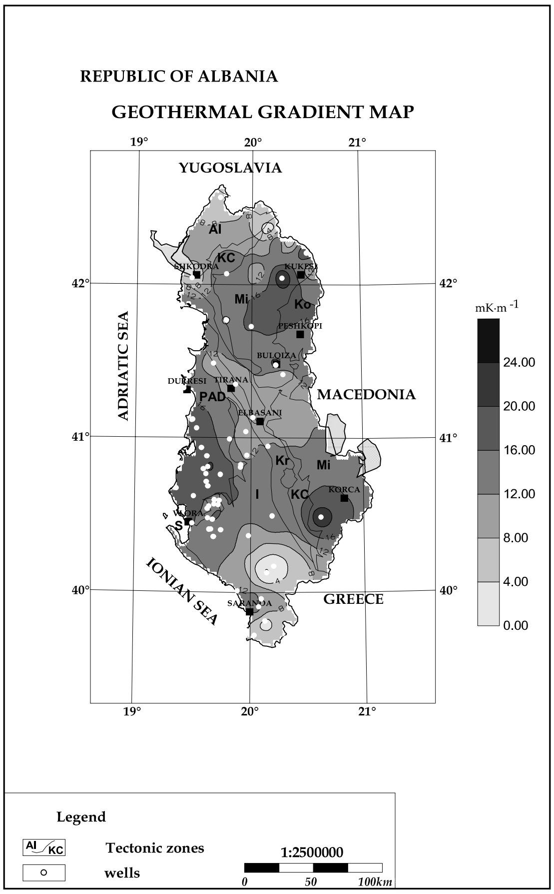


Figure 1.Heat Flow Density Map.

Figure 2. Geothermal Gradient Map.

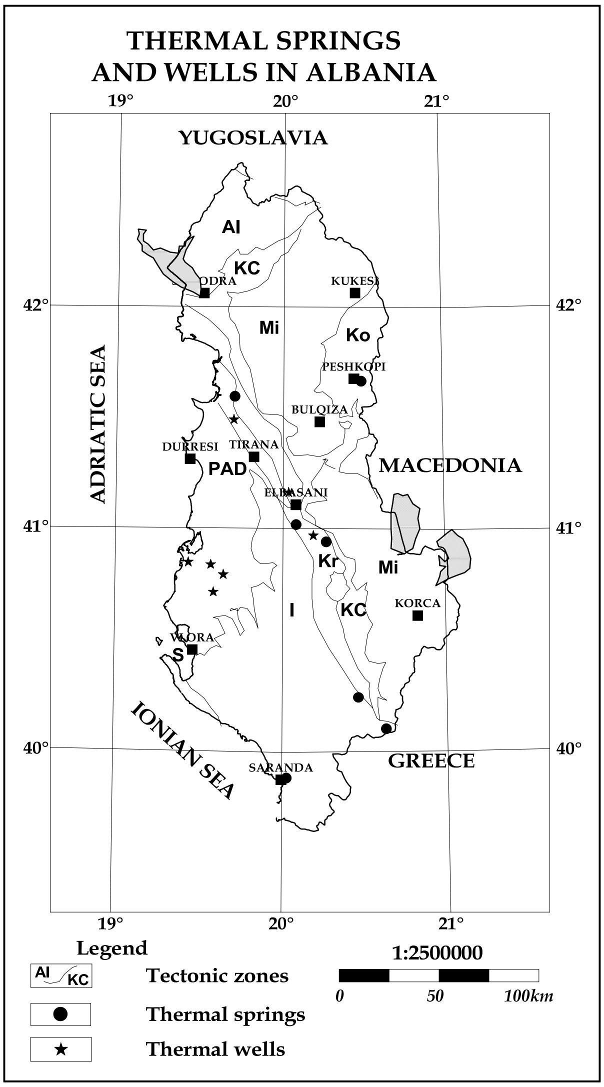


Figure 3. Thermal Springs and Wells.

KARST 2000, INTERNATIONAL SYMPOSIUM AND FIELD SEMINAR ON PRESENT STATE AND FUTURE TRENDS OF KARST STUDIES.
17-26 September, Marmaris. Turkey.

OUTLOOK ON GEOPHYSICAL INVESTIGATION OF KARSTIC ZONES IN ALBANIA.

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ABSTRACT

The paper presents the analysis of the integrated geophysical study results for investigations of the karstic zone in Albania. Electrical profiling and soundings, microgravity and micromagnetic surveys, TURAM and radiowaves methods, refraction seismic of high frequencies, and borehole logging, were included in geophysical complex. Technical construction design and works have been performed according to results of integrated geological-geophysical investigations.

1. INTRODUCTION

Albania is a mountainous Mediterranean country. Geologic, hydrogeologic, geomorphologic and climatic conditions of the country causes the intensive development of karst phenomenon. The karstic formations in Albania are mainly represented by carbonate and evaporite rocks. Triassic, Jurassic, Cretaceous and Paleocene are the ages of karstic carbonate rocks. Groundwater flow through altered and disjunctive tectonic zones of the carbonatic structure causes the tectonic karst development. The presence of the pseudokarstic holes in the subargillite cover in the karstic zones has observed.

There are many rivers streaming from the mountains where seven hydropower plants, with an installed power of 1427 MW have been builds. In Albania, have also been constructed about 250 big water reservoirs for agriculture irrigation purposes. The projection and construction of these works are preceded by detailed integrated geological-geophysical engineering studies. Boreholes have verified the results of these studies. A special attention is given to the study of the karst phenomenon: The detection of the karstic zones, caves, and to evaluated the dynamics of its development from surface to depth. The focus of this study is concentrated also on the loose cover deposits.

The study of the loose cover deposits, the separation of the karstic zone in bedrock and the detection of the cavities have been performed by applied of the electrical soundings and profiling, seismic refraction survey of high frequencies, gravity and magnetic micro-surveys, self potential survey and electromagnetic methods. The zone with unequal development of karst, the karstic lattices in the limestone, and cavities with certain dimension have been isolated. The process of the pseudokarst development in loose deposits has evaluated. The physical-mechanical parameters of the bedrock such as porosity, filtration coefficient, density, modulus of static and dynamic elasticity have been determined. Geophysical surveys have been performed by detailed scale 1:500 and even 1:200, with survey grid (1-2) x (2-5) meters.

The results of the geophysical investigation carry out in the framework of the integrated geological- engineering studies for the detection of the karstic zones, the discovery of the caves and the study of the loose deposits which cover the limestone have been analyzed.

2. GEOLOGICAL SETTING OF THE KARSTIC ZONES AND THEIR PHYSICAL PROPERTIES

Triassic, Jurassic, Cretaceous and Paleocene carbonatic rocks and Permian-Triassic evaporites are represented karstic medium in Albanian Mountains. Average monthly temperature of different areas varies from 2.3-10 up to 17.8-25.9 ^{o}C. The average annual rainfall is more than 1300 mm in Albania. Mediterranean humid climate, rugged relief of the limestone's slope mountains and intensive underground water flowing was created the conditions for development of the karst phenomenon. Are observed open or young karst and old buried karst. Karstic fields, with cuspate microrelief in the valleys, caves, and funnels are extended in the karstic zones. Channels, holes and caves were observed in the subsurface. Karst lattice, micro and macro-fissures are important element of the in karstic zones. Particularly, the karst phenomenon is developed intensively in the riverbed and their slopes. In some cases, the karst cavities are filled with clay or bauxite. The karst phenomenon is also present in the evaporites.

The holes, or pseudo-karst, are observed in the argillite cover mass, over the karstic limestone. Its tops are located at the depth from some centimeter to the some meters. Oval its transversal section has a diameter from some centimeters to 1x1.5 meters.

The petrophysical properties of the rocks in the karstic zones are different from the surrounding environment; therefore the geophysical anomalies can be obtained over karstic zones.

Limestone resistivity varies in wide range, depending by micro and macro fissures, by the lattice of the karst, holes, and the clay content. The compact limestone has resistivity values up to 12 000 Ohm-m. The presence of the clay material decreased the resistivity value. Jointing and karst lattices filled with water or clay material are conducting channels. In these cases, limestone resistivity is decreased up to some tens of Ohm-m Tab.1).

Tab. 1

RESISTIVITY OF THE ROCKS IN KARSTFIED ZONES

ROCKS	RESISTIVITY, in Ohmm		
	Minimal	Maximal	Mode
Grey to white subargille	22	50	30
Subargille	25	60	40
Brown subargille	40	80	60
Reddish subargille	60	150	105
Subargille with carbonate material	110	254	180
Karstic limestone; karst lattices filled with clay	155	400	260
Altered limestone	150	1000	600
Compact limestone	1000	15 500	3000

Loose subargille, silt, sand and rarely gravel, or cemented slope clastic breccia represents the cover deposits over the limestone. All these deposits, generally, have a smaller resistivity than the limestone (Tab. 1). Their resistivity depends by the content of the clay, sandy and even

carbonate material. In the case of the high content of the carbonate, the subargilles have resistivity values between 110 and 254 Ohmm. There is also a relation between the resistivity of pure subargille without carbonate material and the filtration coefficient.

According to the mathematical and physical modeling, over the karst cavities it is possible to observed increasing of the resistivity and their anomalies (Fig. 1, 2). The empty cavities, with a section of 3 m^2 and located at a depth of 5 m, within compact limestone, cause apparent resistivity anomalies. The underground corridors with 2 meters of square section cause weak anomalies. They may be detected at a depth of 3,5-7 m. There are weak anomalies over the chimneys, which are filled with loose clay over on the subargille deposits. If these holes have a diameter of 2 m and occur at a depth of 2-3 m then they are detectable.

Resistivity is changes in vertical direction, too. The subargilles cover deposits represent first geoelectrical layer (Fig. 3). This layer is characterized by the presence of the furrows; holes and funnels as they often filled with altered material. The altered material content is 10-15 %of the rock volume and reach a depth of almost 5 m. Below this layer, there is the second geoelectrical layer, which can be called as the alteration zone. The caves, corridors of the underground channels, which reach up to 10 % of the rock volume, are empty, where the zone is located above the groundwater level. For this reason, the resistivity of second layer is high. The thickness of this layer varies, depending on the karst forms of the limestone and the shape of the relief. The third geoelectriacal layer shows the signature of $\rho_1<\rho_2>\rho_3$. This is because; the less dense karst lattices are filled with water. Lower geoelectrical layer is represented by compact limestone, with higher resistivity than that of all overlying layers. Fig. 3 presents the sounding resistivity curve KH type ($\rho_1<\rho_2>\rho_3<\rho_4$) of karstic zone. Depending on the thickness of layers, A type geoelectric section is also possible ($\rho_1>\rho_2>\rho_3$).

Subargilles, which are filled karstic cavities and lattices have induced polarization chargeability about 20-30 mV/V.

The lattices system and empty karstic elements are caused electrical anisotropy of the limestone. The anisotropy coefficient varies from λ=1.1 up to 4.85. The rose diagram of apparent resistivity in the karstic rocks, have the main directions with discordance by direction of the stratification.

Limestone are characterized by high density, which varies 2440-2700 kg/m^3, with an average values 2660 kg/m^3. Their density depending from the geological age and presence of the micro and macro fissures. The empty caverns are characterized by a density contrast of about 2600 kg / m^3. The mathematical modeling shows that the gravity anomalies caused by small cavities, with a radius of 0.2 m, can be observed only when the cavity top are at the depth 0.3 m, with a minimum amplitude of the Bouguer anomaly of 0.03 mGal (Fig. 4). The huge cavities with a diameter of 15 m may be detected at a depth of 18 m. The density contrast is smaller for the cavities, which are filled with water or clay. Therefore, is decreased the depth of their investigation. The karstic phenomenon is accompanied with the micro and macro fissures. Consequently is decreased the density of the karstic zones. This supplementary reduction of density occurs in a larger area in comparison with the size of the cavern. This causes an increase on the amplitude of the gravity anomalies. Following, the depth of gravity surveys increases. Their density reduces to 1130 kg / m^3 when they are loose and dry.

Magnetic susceptibility (40-120) x10-5 SI units characterize the subargilles. This created the condition for creating of the magnetic anomalies over the karstic caves filled with clay material.

According to the mathematical modeling, the cave with a diameter of 4 m, which is located at 2 m depth, below the Earth surface, can be caused an anomaly with amplitude 5 nT.

Seismic waves velocity decreased up to 1 660 m/sec in karstic limestone, which is three time smaller that velocity of the compact limestone (5 000- 6 000 m/sec).

3. THE SURVEY CONFIGURATION

The petrophysical properties of the rocks in the karstic zones are different from the surrounding environment; therefore geophysical anomalies can be obtained over karst zones.

The application of geophysical methods has been necessary, and these methods have been priority over the other classical geological exploration methods, especially for the study of the covered loose deposits over the karstic rocks. The purpose of the geophysical surveys is the discrimination of the zones, which need a special care during the construction of the hydrotechnical works, to avoid filtration and to prevent constructions against the action of the hydrodynamic and hydrostatic pressures. The thickness of the loose covering deposits and their layered structure has been determined. The variations of the top of bedrock and the relation between the loose deposits and bedrock have been investigated. The structure of the bedrock was performed. The zones with unequal development of karst and the karst lattices in the limestone and particular caves have been isolated. The process of the karst development, and the physical-mechanical parameters of the bed-rocks and loose deposits such as porosity, filtration coefficient, density, modulus of static and dynamics elasticity have been evaluated.

Such a broad scope of the problems to be solved by geophysics made necessary the application of surveys by the very detailed scales, 1:500 and even 1:200. Survey grid has been (1-2) x (2-5) m. Have been applied different methods, such as electrical profiling and soundings, gravity and magnetic micro-surveys, self- potential and induced polarization survey, radiowave method, TURAM method, high frequency seismic refraction surveys, and borehole logging.

Electrical profiling were performed with multiple Schlumberger array $A_1A_2A_3MNB_3B_2B_1$. Volumes of the 5-25 % from the electrical soundings were performed with multidirectional array, to electric anisotropy study. Electrical profiling have been carried out by pol-dipol array AMN, $B\rightarrow\infty$, with spacing AO = 10- 300 m. The surveys were performed in two levels:
- In the upper level, at a depth of 10 m, for the search of cavities in the loose cover, and
- In the limestone near the surface, as well as in the lover level, to detect the karst cavities within the limestone.

In some cases have been used the TURAM survey and the method of radio waves with frequencies up to 10 MHz. Induced polarization survey have been applied for the selection of the cavities filled with clay from cavities filled with water. The self- potential surveys have been carried out before and after the raining. The electrical measurements have been conducted with RDC-10 SCINTREX receiver.

The gravity survey has been carried out by a gravimeter with a sensitivity of 0. 01 mGal. Short measured period, than 1 hour, has permitted the observation of anomalies with amplitude of 0.1 mGal. The gravity survey was used prior the other geophysical methods for finding the karst cavities.

The magnetic survey were done with the proton magnetometer of they type MP-2 SCINTREX with sensitivity of 1 nT. Measured values were corrected for diurnal variation. The mean average square error of the surveys was not more than 4-5 nT. Magnetic micro-survey is used for selection of the caves filled with clays from the empty ones.

Seismic refraction surveys were conducted with a 6-trace seismograph. In every channel longitudinal (P) and the transverse (S) waves were recorded, at a distance 0; 2; 3; 5; 10 and 25 m.

For investigation of the underground water infiltration ways have been carried out self-potential surveys. Surveys were performed during the dry period and after the rains. Self-potential anomalies have great amplitude when are observed after the rain. In this case, the water infiltration process is developed intensively and the anomalies are amplified.

Electrical (resistivity and self- polarization-SP) and gamma-ray logs also carried out in boreholes with. The logging plots recording were conducted at scale 1: 50. The correlation between the physical and mechanical properties is made by statistical methods by using the results of in situ and laboratory sample measurements.

4. DISCUSSIONS OF THE RESULTS

The results of geophysical surveys carried out in some karstic zones in Albania will be analyzed.

The water reservoir, near of the Shkodra city in Northwest part of Albania, is located over the Triassic-Jurassic karstic limestone. Clays, subargilles, silt and sand of deluvial- provulial loose deposits are covered the karstic limestone. According to the electrical sounding results, loose cover deposits have a thickness, which varies from 1-2 m to 26 m. In some sectors of the reservoir area were observed the KH and HA types sounding curves are of (Fig. 5). The karst phenomenon is developed in these sectors. There are observed also an electrical anisotropy of the limestone. In the deepest sectors of the valley, the karstic limestone are eroded. Consequently, were observed two-layers sounding.

Resistivity and gravity anomalies have been observed also over the limestone blocks or deepening of the limestone top. Fig. 6 presents the Bouguer anomaly map in irrigation reservoir in Vlora district in southwestern coastal zones of Albania. Reservoir is located over a Jurassic-Cretaceous karstic carbonate and carbonate-clay breccia formation. There are observed five Bouguer anomalies (Fig. 6). Anomalies G-1, G-2, and G-3, according to the complex interpretation of the gravity survey data and electrical profiling and soundings, have been concluded that these anomalies are located over the sectors where is increased the thickness of the loose cover deposits. Anomalies G-3 and G-4 are coincided with the Self-Potential anomalies. This fact is an argument for the kartic origin of the gravity anomalies G-3 and G-4.

The karst cavities and lattices which are filled with clay, have been selected by magnetic and the induced polarization data. Over these sectors, magnetic and induced polarization anomalies are observed (Fig. 5). These sectors are also clearly seen in the borehole logging plots, by increasing of the intensity of natural gamma radiation.

The karstic zones were also observed by refraction seismic surveys. In the time sections have been indicated that there is a three layered section in the right one. The upper layer has a wave propagation velocity of V_1= 3100 m/sec, the second one V_2 = 1660 m/sec and the third one V_3 =

5000 m/sec. The second layer, with low seismic wave velocity, shows the presence of the karstic limestone.

Fig. 6 presents the field-potential anomalies in the irrigation reservoir. The self-potential anomalies have been well contoured the water infiltration ways.

The loose clay and subargilles deposits, that cover the limestone in the studied karst zones, have relatively higher resistivity values, varying between 20 and 80 Ohm-m. This reveals that they are carbonatic or permeable. In different reservoirs, some holes were found in the loose deposits, that covers the karstic limestone. Over these holes, a maximum of the apparent resistivity and minimum of the gravity force were observed (Fig. 7). Both are weak anomalies. Resistivity anomalies have the amplitude about 20-50 Ohmm. These anomalies are also similar to the anomalies are observed also in buried limestone block. The density of the clays and subargillites varies between 1800 kg / m^3 and 2000 kg / m^3. The amplitude of the gravity anomalies is increased for the second derivative of the vertical component of the gravity g_{zz}. But, such minimum are found also in cases where the thickness of the loose deposits increases. Consequently, the resistivity method and gravity survey is necessary to use in complex.

5.CONCLUSIONS

1) Karstic zones and the underground cavity detection have been performed effectively by the integrated geophysical methods.

2) The karstic zones can be separated from the compact limestone by the KH and HA or A type of the resistivity sounding curves and by the electrical anisotropy. In addition to the resistivity method, have been used the high frequency seismic refraction surveys. The caverns that have a radius about 1 m and are located close to Earth surface have been detected by using conventional gravimeter with sensitivity of 0. 01 mgal.

3) Selection of the caverns filled with clay was performed by application of the induced polarization soundings and magnetic micro-survey, in complex with the resistivity soundings. Good results are also obtained by the method of high frequency radio-waves method, with a frequency up to 10 MHz, during the salt mine investigation.

4) Detection of the holes in the loose subargille cover deposits is possible to be performed by the electrical profiling and the gravity surveys.

5) The boreholes logging, electrical, radioactive and acoustic logs, have been permit to evaluated physical properties of the rocks and loose deposits, and verify results of the geophysical surveys. The evaluation of the physical properties is necessary to base also in the laboratory determination of the samples.

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Fig. 1. Amplitude of the anomalies of the apparent resistivity over a cubic cave, according to the 2D physical modeling. Top of the cave is located at depth 7 m. Cubic side 5 and 15 m (a/h=0.71 and 2.14).

Fig. 2. Amplitude of the anomalies of the apparent resistivity over a vertical prismatic cave, according to the 2D physical modeling. Top of the cave is located cave at depth 15 m. Prism has a base 2 m and height 10 meters.

Fig. 3. Resistivity and Induced Polarization sounding curves over a vide karstic cave and filled with water cave.

Fig. 4. Dependence of the radius of sphere cave by depth of their top. Cave is caused gravity anomaly with an amplitude 0.03 mGal. Filled with water cave has a density contrast -1600 kg/m^3 and empty cave –2600 kg/m^3.

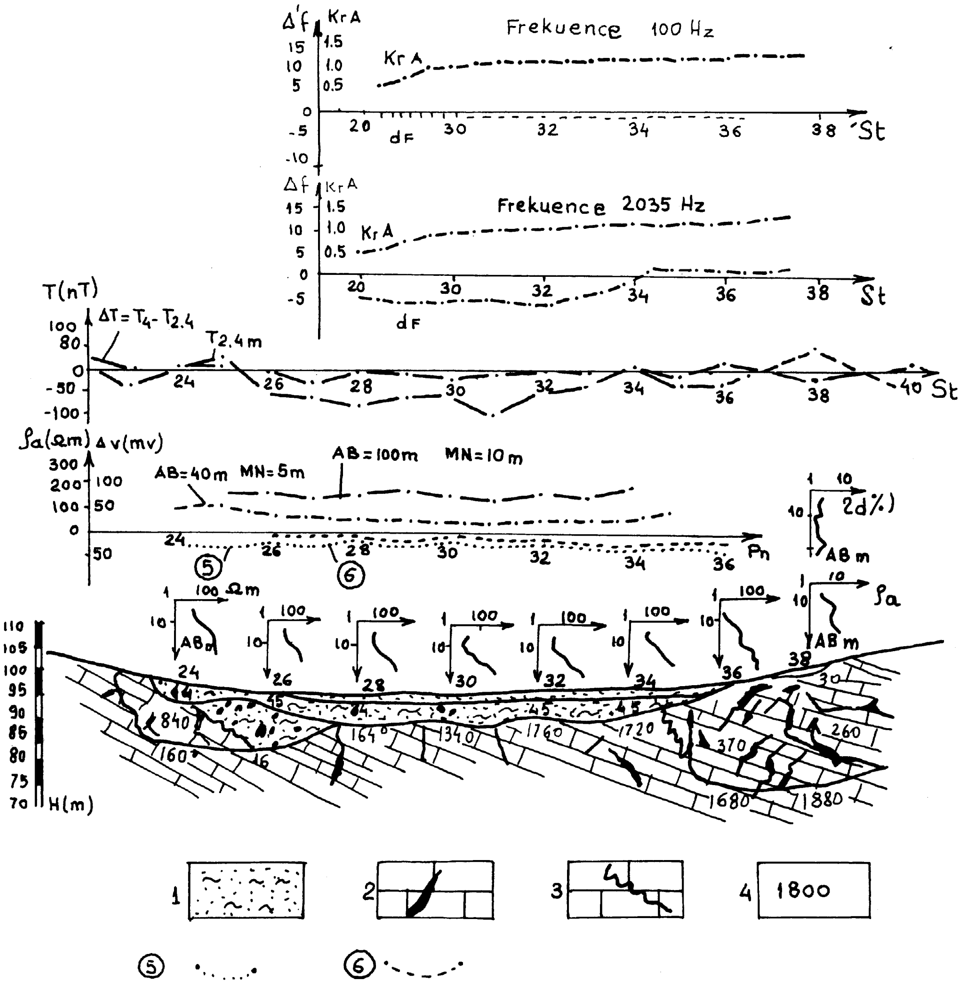

Fig. 5. Integrated geologic-geophysical section of the observed line in the reservoir near of the Shkodra city.

1. Subargille cover; 2. Intensive karstified limestone; 3. Karstified limestone; 4. The values of the resistivity, in Ohmm; 5. Self-Potential observed after the rain; 6. Self-Potential observed in dry weather.

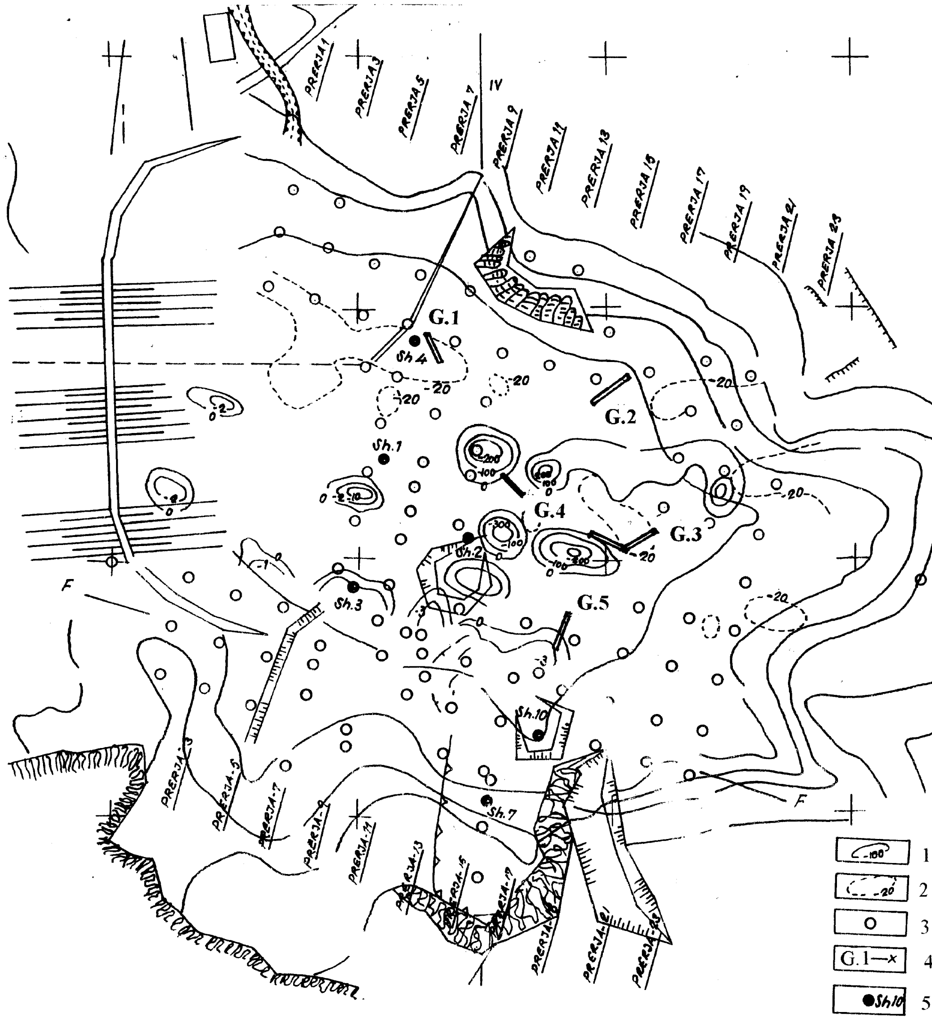

Fig. 6. Bouguer anomalies and Self-potential anomalies in the reservoir near in the Vlora district.

1. Self-potential contours observed in dry period; 2- Self-potential contours observed after the rain; 3- G.1- G.5- Bouguer anomaly axis; 4- Electric sounding center; 5- Borehole.

Fig. 7.

PROCEEDINGS, Twenty-Sixth Workshop on Geothermal Reservoir Engineering
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“OUTLOOK ON PRINCIPLES FOR PROJECTING OF INTEGRATED AND CASCADE USE OF GEOTHERMAL ENERGY OF LOW ENTHALPY IN ALBANIA".

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INTRODUCTION

In the countries of Western Europe, USA and Japan, the technologies of a new generation evolved to exploit high and low enthalpy geothermal sources and mineral waters. There are great experiences for modern complex exploitation of these resources, which increase natural wealth values, in European Community Countries.

In Albania, rich in geothermal resources of low enthalpy and mineral waters, similar new technologies have been either partly developed or remain still untouched. Modern complex exploitation is very rare phenomena.

Large numbers of geothermal energy of high and low enthalpy resources, a lot of mineral water sources and some CO_2 gas reservoirs represent the base for successfully application of modern technologies in Albania, to achieve economic effectively and success of complex exploitation.

Actuality, there are many geothermal, hydrogeological, hydrochemical, biological and medical investigations and studies of thermal and mineral water resources carried out in Albania. Generally, these investigations and studies are separated each from the other. Their information and data will serve for studies and evaluations in Albania regional scale. These studies and evaluations are necessary to well know in regional plane the thermal and mineral water resources potential and geothermal market of the Albania. According to results of these new studies, the evaluation for the perspective level of the best areas in country will be necessary. After the evaluation is possible to start investments in these areas. These investments will be profitable in a short period of time.

Integrated and cascade use of geothermal energy of low enthalpy it is important condition for profitable investment.

1. OVERLOOK ON NATURAL ENERGETIC RESOURCES IN ALBANIA

Albania is a mountainous Mediterranean country with numerous natural energetic resources. Albania has a total surface 28 748 km^2 , where 70-75% of the territory is composed of mountains, hills, lakes and rivers. There are many rivers flowing from the mountains. The total hydrographic chatchment area surface of Albania is about 40 000 km^2 The average level of the hydrographic network is 700 m. Albania is a country with relatively high precipitation. In its hydrographic area fall in average 1 400 mm rain per year. Its snows in the levels over 1 000 m in mountain areas. 70% of the river water flows observed during the winter and spring. During a year from all Albanian Rivers flows in sea about 39 billion m^3 water. The average perennial total inflow of Albanian Rivers is about 1 245 m^3/sec. of One of main Albanian rivers, Drini River in Northern Albania, has an average inflow about 340 m^3/sec.

According to Preliminary Feasibility Studies result that the hydro-energetic potential of Albania for the exploitation reach about 16 000 GWh per year.

Hydroenergetic resources represent most important energetic resources of Albania. Seven hydro-power plants have been built, with an installed power of 1446 MW. Fierza, Komani and Vau Dejes Hydroelectro power plants have been constructed in Drini River, with an installed power, 500 MW, 600 MW and 250 MW, respectively. Electric energy production is 5 000 GWh in 1999. From 58 small hydroelectric power plants were produced only 0.23% of the

energy of hydroalectric energetic system of Albania.

Until now it is utilized about 30% of the hydro-energetic potential of Albania.

There are about 20 oil and gas reservoirs under exploitation in Albania, producing about 2.4 Mt oil in 1974, but within the last years the production is decreased and in 1999 only about 340 Kt of oil were extracted.

There are tens of coalmines in Albania, with an output of over 2.2 Mt coal in 1989 and 420 Kt of coal in 1995. In 1999 the production is under 50 Kt of coal.

Thermoelectric power plants have an installed power about 213 MW, and production has been 182 million kWh during 1999. Fieri Thermoelectric Power Plant is most important, with an installed power 160 MW.

The Albanian energetic system is mainly based on electricity produced by hydropower plants. The climate of Albania is a typical Mediterranean one, with a hot and dry summer. This climate makes the electrical system (based on the water resources of Albania) very capricious.

In the present conditions of a new Albanian market economy, together with the transformations in the management of existing energetic system, the study of other energetic sources has begun. There are great possibilities to use renewable energies.

Solar energy is most important of renewable energies in Albania. Albania is a country with great sunshine period during the year, from 2731 o'clock/year in the Southern Albania, 2 560 o'clock/year in the Tirana region and 2046 o'clock/year in Northern Albanian regions (Climate of Albania, 1978).

Solar heat in Albania has an average value about 129.3 $Kcal \cdot cm^{-1} \cdot year^{-1}$. The use of the solar panels for the direct solar energy exploitation will have a great importance in Albania.

Wind energy exploitation in Albania is important, too. In the coastal areas the average wind speed is about 2.8-3.8 $m \cdot sec^{-1}$ (Climate of Albania, 1978). There are many regions where the wind speed is several times greater than that in the above-mentioned regions, 35-45 m/sec in coastal areas and 20-35 m/sec in the other regions. This is another important source of renewable energy.

In Albania there are also many thermal water springs and wells of low enthalpy, with a temperature of up to 65.5°C, which indicates that it is possible direct use of the geothermal energy.

2. GEOTHERMAL ENERGY IN ALBANIA

2.1 Geological Features

The Albanides form an integral part of the southern branch of the Mediterranean Alpine orogen. They are subdivided in two zones: the Internal and the External Albanides. The geology of Albanides creates the premises for the research and exploitation of natural geothermal energetic resources.

The results of the geothermal studies carried out in Albania are presented in maps and geothermal sections. Temperature maps have been drowning for different levels of up to 5000m depth. Geothermal gradient, heat flow density and geothermal resources maps have also been drawn. The natural springs with thermal waters and the geological structures with high water temperature have also been mapped. The water basins with higher average temperature than that of yearly average in one of the regions has been studied as well. The study of the possibility of exploitation of abandoned deep oil wells as "Vertical Earth Heat Probes" has already begun.

The greatest heat flow density with a value of 42 $mW \cdot m^{-2}$ is found in the center of the Preadriatic Depression (Fig. 1). In the east of the ophiolitic belt heat flow density reaches values of up to 60 $mW \cdot m^{-2}$.

The temperature varies from a minimum of 12°C at a depth of 100m up to 105.8°C at a depth of 6000m. In the central part of the Preadriatic Depression, there are many deep oil wells where the temperature reaches up to 68°C at a depth of 3000m. The isotherm runs in a direction that fits that of the strike of the Albanides. The configuration of the isotherm is the same down to a depth of 6000m. Going deeper and deeper the zones of highest temperature move in a direction southeast to northwest, towards the center of the Preadriatic Depression and even further towards the northwestern coast.

The geothermal gradient has the highest value about 18.7 $mK \cdot m^{-1}$ in the center of the Preadriatic Depression. Elsewhere the gradient is mostly 15 $mK \cdot m^{-1}$ (Fig. 2). In the south of the country the geothermal gradient has low values 11.5-13 $mK \cdot m^{-1}$. The lowest gradient value of 7-11 $Mk \cdot m^{-1}$ is found in the deep synclinal belts. Towards the northeastern and southeastern regions of Albania, over the ophiolitic belt, the geothermal gradient increases, reaching the value of 23.5 $mK \cdot m^{-1}$.

2.2. Geothermal Areas and Reservoirs

In Albania there are many thermal springs and wells of low enthalpy. Their water has temperatures that reach values of up to 60°C (Fig. 3).
Table 1 presents some data on the water temperature for such springs.

Table 1
THE THERMAL WATER SPRINGS IN ALBANIA

N° of Springs	Location	Temperature in °C	Salt in mg/l	Artesian Spring yield in l·s-1
1	Llixha Elbasan	60	0.3	0
2	Peshkopi	5-43	9	10
3	Krane-Sarande	34		<10
4	Langareci-Permet	6-31		>10
5	Shupal-Tirana	29.5		10
6	Sarandoporo-Leskovik	26.7		>10
7	Tervoll-Gramsh	24		>10
8	Mamurras-Tirane	21	26	>10

These thermal water springs are mainly near zones of regional tectonic fractures. Generally the water circulates through carbonatic rocks of the structures and evaporitic beds at some kilometers of depth. The water of these springs contains salt, absorbed gas and organic matter. They are sulfide: methane, iodine-bromium and sulfate types.
In many deep oil and gas wells there are thermal water fountain outputs with a temperature that varies from 32 to 65.5°C (table 2)

Table 2
THE OIL AND GAS WELLS THAT HAVE SELF-DISCHARGE OF THE THERMAL WATER

N°	Well Name	Temperature in °C	Salt in $mg \cdot l^{-1}$	Self-discharge, in $l.sec^{-1}$
1	Kozani-8	65.5	4.6	10.4
2	Ishmi 1/b	64	19.3	4.4
3	Galigati 2	45-50	5.7	0.9
4	Bubullima 5	48-50	35	
5	Ardenica 3	38		15-18
6	Ardenica 12	32		
7	Semani1	35		5
8	Verbasi 2	29.3		1-3

These waters comes from different depth levels (800-3000 m) of limestone reservoirs (wells 1, 2, 3, 4) and sandstone reservoirs (wells 5, 6, 7 and 8).

Until now the thermal waters of the springs 1, 2, 4, and 6 and wells 1, 2, 3 in Albania are used only for health purposes. These waters may be used for heating purposes, green houses,

aquaculture, and thermal pool for tourists, extraction of the microelements and natural salts as well.

In conclusion, reservoir is a heterogeneous collector and its thermo-hydrodynamic regime is stable in Kruja geothermal area. We could find other springs with greater geothermal resources, higher yield and water temperature we may expect in this geothermal area. For that, it is necessary that hydrogeological and geophysical investigations to carried out and new wells be drilled in order to capture the water deeper where the temperature is higher.

2.3. Directions for the exploitation of geothermal energy of low enthalpy in Albania

The geothermal situation of low enthalpy in Albania offers two directions for the exploitation of geothermal energy, which is unused until now.

- First, thermal sources of low enthalpy and of maximal temperature up to 80°C. These are natural sources or wells in a wide territory of Albania, from the South near Albanian-Greek boundary to North-east districts in Diber Region.

Thermal waters of springs and wells in Albania may be used in several ways:

1. For SPA clinics for treatment of different diseases and
   hotels for development of Eco-tourism.

Such centers may attract a lot of clients not only from Albania, because not only the good curative properties of these waters but also because they are situated in nice places near sea side, mountains or Ohrid lake.

2. The hot water of SPA may be used also for heating of hotels, SPA and tourist centers, as well as for the preparation of hot water used there.

Near these SPA it is possible to built :

- greenhouses for flowers and vegetables
- acqua-culture installations.

3. From thermal waters it is possible to extract very useful chemical microelements as iodium, bromium, chlor etc. and other natural salts, so necessary for preparation of pomades for the treatment of many skin diseases as well as for beauty treatments. From these waters it is possible to extract sulphidric and carbonic gas, the former is well known for special treatments of breathing ways, the later for treatment of food. It is possible to built installations for processing of thermal waters. Such developments are useful also for the creation of new working places and improvement of the level of life for local communities near thermal sources.

The sources of low enthalpy geothermal energy in Albania, which are at the same time the sources of multi-element mineral waters, they represent the basis for a successful use of modern technologies for a *complex and cascade exploitation* of this energy, achieving a economical effectiveness.

- **Second,** the use of deep doublet abandoned oil and gas wells and single wells for geothermal energy, in the form of a “Vertical Earth Heat Probe”. The geothermal gradient of the Albanian Sedimentary Basin has average values of about 18.7 $mK \cdot m^{-1}$. At 2 000 m depth the temperature reaches a value of about 48°C. In these single abandoned wells a closed circuit water system can be installed. This “Vertical Earth Heat Probe”, by means of water conversion, is coupled with the heat transfer from the surrounding rocks downwards, to be finally recovered in the tubes.

Actually in Albania the study of the possibilities of exploitation of the geothermal energy has begun.

3. ALBANIAN GEOTHERMAL ENERGY MARKET

Objectives of market study:

- Evaluation of present status of geothermal development in Europe, regarding promotion activities, results, application, barriers for market penetration, legal and financial framework, etc.
- Comparison of present status between the countries involved
- Identification of the attitude and feelings (awareness, knowledge, preference, etc.) for the target groups towards geothermal energy.
- Identification of the attitude and feelings of the target groups towards environmental aspects of geothermal energy.

- Evaluation of the outcome of promotion methods adopted by EU and national institutions
- Formulation of proposals for effective promotion strategies for geothermal energy in Albania.

Amend above proposals in order to transform them to effective promotion strategies for geothermal technologies in Albania.

3.1. Consumers for geothermal energy & thermal water (heat, spa, cooling, power production, drinking water, acqua-culture, agriculture)

In the present some SPA, with a primitive technology, worked in geothermal springs and wells in Albania: Lixha Elbasani, Bilaj Balneological Center (Ishmi 1/b well), Peshkopia (Diber district) SPA, Langarica (Leskovik Disrict) SPA, Langarica-Ura Kadiut (Permeti District) SPA.

The oldest and important is **Elbasani Llixha SPA,** which located about 10 km south of Elbasani city and 61 km in south-east of Tirana, in the Central part of Albania. By national road communication, Llixha area is connected with Elbasani and Tirana. Only 10 km will be from the highway Durresi- Skopje- Sofia- Istanbul, which is projected for construction in the future and nominated as No. 8 European Corridor. The proximity with highways create great possibilities for **Elbasani Lixha SPA to be a nice place. This area may be frequented by a large number of people from different Balkan countries, Italy, UK, Germany, Ostrich, France, Low Countries**, and by Albanians from Albania, Macedonia and Kosovo as well. these thermal springs From about 2000 are know years ago. According to historic data, in Elbasani Llixha thermal springs there has been an inn, near of the old road “Via Egnatia" that has passed from Durresi to Constantinople.

There are seven spring groups that extends like a belt with 320^{o} azimuth. Surface water temperature is about 60^{o}C and yield in total 15 l/sec. Springs have constant hot water yield and temperature for a long period of time. These data are evidence of a stable thermo-hydrodinamic reservoir regime.

Before the Second World War, in one from the springs (“Nosi spring”) has been constructed “ PARK-NOSI” SPA (∗∗∗), with 166 beds, for medical treatment of various diseases, generally rheumatic. The “NOSI” SPA functioned during a period of time more than 60 years and for the present is private property. Land with surface of 20 000 m^2, hotel and restaurant are owned by PARK NOSI Sh.p.k.. Particularly reconstructed hotel after the privatization actually is in work. Near this property there is located a public hotel, with 180 beds, almost in destruction state, but which may be reconstruct.

Albanian patients treated for rheumatism and various illnesses in Elbasani Lixha SPA are:

in 1990	7899 persons	
1992	4659 persons	(Transition Period)
1993	4908 persons	
1994	3603 persons	(after the privatization, only in Park NOSI Hotel)
1995	3800 persons	(after the privatization, only in Park NOSI Hotel)

The events in the first half of 1997 year in Albania, have caused a decrease of the numbers of patients in PARK-Nosi SPA (∗∗). After the stabilization of the situation in Albania started the increase of SPA frequenting

The price in PARK-Nosi SPA, for day’s treatment (hotel, meal and treatment) in SPA, for Albanian patient, in actual economical situation, has been:

in 1990 1.84 USD
in 1996 680 lek = 7.16 USD (1 USD = 95 lek)
in 1997 680 lek = 4.68 USD (1 USD = 145 lek) (inflation result)
in 1999 1000 lek = 7.4 USD (1 USD = 135 lek)
VAT 20% is included in the price.

This is a more chipper price compared with hotels in Elbasani city, regarding accommodation and breakfast only. **From 30 to 240 USD per day is the price in Tirana hotels.**

About this price, it is necessary to expose the following:

In the future, the increase of price for daily treatment of the patient in SPA. will increase also the profit, according to:

Firstly, amelioration of the medical treatment, the accommodation and food conditions in the SPA.

Secondly, from foreign and Albanian patients the SPA frequenting demand will increase, according to new situation of the supply and demand.

Thirdly, the life level of Albanian people will increase

Fourthly, SPA frequenting by Albanians from Macedonia and Kosovo, which have more high economic level.

Fifthly, European patients and tourists will start to frequent the New SPA, by creating the best condition for medical treatment and tourism for them.

Land price in Elbasani region, in 1996, has been 5-7 USD/m^2.

Actually, there is not a law for thermal waters in Albania. The PARK NOSI Sh.p.k. Llixha Elbasani, is using thermal spring as ex-owner of SPA before the Second World War. SPA in Ishmi well area has privates in 1993.

All seven groups of the springs in Llixha Elbasani and Kozani-8 well geothermal area will have the possibilities for modern complex exploitation. The beautiful landscape of Elbasani Lixha area will be not only for medical treatment but also as tourist place. This area located near of the very know Ohrid Lake pearl or mountains Gjinari, with their fantastic forests and nice climate.

Ishmi 1/b geothermal well is located in beautiful Tirana field, near of Rinasi (Tirana) Airport, near of the Adriatic coastline and Kruja - Skendergeg Mountain. There are all the possibilities for the echo-tourism development: thermal water, Ishmi beach at the Adreatic Sea , and mountain’s area.

3.2. Geological risk, financial possibilities to cover geological risk

No geological risk for the exploitation of thermal water of geothermal springs and wells in Albania.

3.3. Traffic connections: roads, railways, navigation, and possibilities for transport of heavy goods

The **Ishmi-1/b well** is located in Ishmi area and represents the northernmost geothermal well of the Kruja geothermal area. It is located in 20 kilometers NW of Tirana (near of Rinasi-Tirana Airport). By national road communication, Ishmi 1/b well is connected with Tirana, Tirana Airport, Durresi and Shkodra cities.

Kozani-8 well is located 35 kilometers southeast of Tirana, on hill’s area. Well connected by 1.7 km road with Tirana-Elbasani national road, and hightway “Corridor 8” Durresi-Elbasan-Scopje. One km from Kozani 8 well located Saint George Vladimir Monastery.

Elbasani Llixha SPA is located about 12 km south of Elbasani city and 61 km in south-east of Tirana, in the Central part of Albania. By national road communication, Llixha area is connected with Elbasani and Tirana. Only 10 km will be from the highway Durresi- Skopje- Sofia-Istanbul, which is projected for construction in the future and nominated as No. 8 European Corridor. These thermal springs from about 2000 are known years ago. According to historic data, in Elbasani Llixha thermal springs there has been an inn, near of the old road “Via Egnatia" that has passed from Durresi to Constantinople.

4. THE AIMS AND OBJECTIVES OF THE PROJECT

4.1. The aims of the project

To examine, demonstrate and disseminate the positive technical and financial aspects of transfer and utilization of innovative geothermal energy technologies in Albania, which will have a direct impact in the development of the regions by increasing their per capita income and at the same time ameliorating the standard of living of the people.

This development will be achieve in parallel with the reduction of any negative environmental effect, which would have followed this type of development if older geothermal energy technology or even conventional sources of energy were to be utilized. Significant financial, social and technical benefits will arise from the promotion and final application of the results of this project.

4.2. Objectives:

Integrated exploitation and cascade direct use of the geothermal energy has projected.

The objectives of the project:

4.1. Geothermal energy and mineral water resources evaluation of country

4.2. In-situ detailed investigation of the pre-selected zones with high energy potential & consumers geothermal source, where will installed demonstrative unit.

Among others this task will be concerned with:

- -Intentions of users-thermal load inspections
- -Initial energy balance analyses
- -Thermal characteristics of individual users
- -Technical geothermal data collection
- -Examination of existing technology

It is necessary to select the thermal applications, which correspond to the local needs. The following will be defined:

a) In situ consideration of geothermal physical-chemical parameters and potential
b) Thermal load demands for space heating for each end-user of geothermal sources:

- - Dwellings,
- - Geothermal SPA,
- - Greenhouses,
- - Geothermal pools, etc.,
- -. Aquaculture,
- - Mineral waters production
- - Extraction of the micro-elements and natural salts

b) Energy balance between different end-users,
c) Technologies to be applied
d) Preliminary design of the geothermal energy exploitation system
e) Definition of thermal demands
i) Energy conservation, and
k) Economic evaluation of thermal energy (space heating and hot water production installation cost, life cycle, energy product cost, pay back period). This evaluation will be based on actual market prices for equipment, construction etc.

Based on the above analysis, for the best area selected, a Feasibility Study will be performed to analyze three components: energy supply, environmental impact and financial aspects, and to suggest the best solution of the innovative geothermal energy utilization technology applications in that area.

4.3. Environmental protection and preserving level will be improved, to well assist the echo-system protection of thermal and mineral water source areas.

Among other subjects this phase will focus mainly on:

-Examination of the nature of the geothermal fluid
-Environmental impact of the geothermal fluids during their utilization and disposition
- Selection of the most acceptable environmentally methods for the disposal of the geothermal fluids

4.4. The concrete detailed design for the implementation phase of the Project will be prepared.

Task 1. Demonstrative units (pilot plants) will be constructed, monitored and finally demonstrated. These demonstrative units will assist in the promotion of the new innovative technology application facilitating in parallel the transfer of this innovative technology to end users as well as industrial production.

The proposed schemes represent an integrated scheme and cascade scheme for exploitation of geothermal energy. This exploitation will realized by integrated scheme of geothermal energy, heat pumps and solar energy to fulfil. This scheme has an environmental benefit by using renewable energies (geothermal energy, solar energy), new technologies (heat pumps) and energy savings (cascade scheme).

Cascade scheme should be used to fulfil the thermal energy demand for the selected area in order to get the maximum benefit from geothermal energy and the minimum energy supply from heat pumps: the promotion of energy savings will be in place.

These demonstrative units will make researcher and scientists aware, on-site, of specific plant operational problems, new technology implementation problems and finally assist to their in situ solution.

These pilot demonstrative units will help potential users overcome psychological barriers towards the utilization of new innovative technologies for direct application.

Task 2: A promotion and tourist agency will be organized. This agency will prepare the reclaims and booking of the rooms for Albanian and foreign patients.

5. APPLICATION AND TRANSFER TECHNOLOGY FOR A COMPLEX AND CASCADE EXPLOITATION OF GEOTHERMAL ENERGY

5.1. Construction of thermal supply installations:

1. Installation of pipe – distribution system
2. Heat exchanger
2. Distributors
3. Control Room-Monitoring.

5.2. Construction of the experimental units for exploitation of the geothermal energy:

1. Building of SPA, with 30-40 beds, for the medical treatment (gynecological and rheumatic diseases),
2. Construction of heating installation in the buildings
3. Construction of the greenhouse for the flower.
4. Construction of the greenhouse for the legumes.
5. Construction of thermal pool for tourists, wardrobe and bar.
6. Installation of equipment for extraction microelements and natural salts.

5.2. Feasibility Study

Technical and financial feasibility study for innovative geothermal energy utilization technology applications. Market penetration of geothermal energy.

Economic evaluation should include:

- First investments for the proposed schemes (integrated scheme, cascade scheme);

• Evaluation of thermal energy (space heating and hot water production) unit cost produced by integrated scheme: geothermal energy, heat pumps and solar energy;

• Evaluation of benefits (in financial terms) through comparison with the classical scheme of the proposed integrated and cascades scheme;

• Other benefits will be assessed for example the environmental benefit by using renewable energies (geothermal energy, solar energy), new technologies (heat pumps) and energy savings (cascade scheme).

Among others and for one of the two application cases this phase will be examine:

-Preliminary consideration for each case
-Definition of the main parameters affecting each system
-Analysis of the effect of the different parameters
-Selection of the "basic" application cases/techniques
-Design of the system
-Selection of alternative cases
-Final technical conclusions

Based on the above analysis, for the best area selected, a Feasibility Study will be performed to analyze three components: energy supply, environmental impact and financial aspects, and to suggest the best solution of the innovative geothermal energy utilization technology applications in that area.

6. PRELIMINARY COST FOR THE INVESTMENT

Cost estimation is carried out only for the first phases, to realize investment step by step:

No	Object	Cost, in USD
1	Reconstruction of heating and thermal baths	50 000
2	Construction of two thermal water unit equipment's	80 000
	Construction of green houses, 2 * surface 3 000 m^2	240 000
4	Construction of new SPA Clinic and for new hotel building), (****)	2 200 000
5	Feasibility study and project idea	53 000
9	Other Expenditures	20 000
10	Overhead rate TOTAL exc. VAT	15 000 2 418 000

7. ECONOMICAL-FINANCIAL EVALUATIONS

HOTEL-SPA, First Phase: 25 bed rooms, 40 beds.

Currency: USD Inflation rate: 3.5%

Table 1

Economic bases	Years				
	1st	2nd	3rd	4th	5th
1. Number of rooms (1)	25	25	25	25	25
2. Number of beds	40	40	40	40	40
3. Days of operation	280	280	280	290	290
4. Food&beverages-facilities	280	280	280	290	290
5. Guest structure and room price					
6. Average room occupancy	100%	100%	100%	100%	100%
7. Average room price					
	72	74	75	75	75
	50	50	55	55	60

1) Hotel has 15 doubles rooms and 10 single rooms
   Rata: Single room 50 USD; Double room 70 USD (Include VAT) (Present room's rate in *** Hotels in Tirana)

Supplementary facilities:

1. Outdoor-indoor thermal & swimming pool
2. Ball sports (tennis, volleyball, basketball)
3. Recreation (sauna, Turkish bath, solarium)
4. Fitness Center with aerobic
5. Restaurant, bar
6. Meeting room
7. Others (rent a car, coiffeur, boutiques)

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The objectives of the project:

4.1. Geothermal energy and mineral water resources evaluation of country

4.2. In-situ detailed investigation of the pre-selected zones with high energy potential & consumers geothermal source, where will installed demonstrative unit.

Among others this task will be concerned with:

- -Intentions of users-thermal load inspections
- -Initial energy balance analyses
- -Thermal characteristics of individual users
- -Technical geothermal data collection
- -Examination of existing technology

It is necessary to select the thermal applications, which correspond to the local needs. The following will be defined:

a) In situ consideration of geothermal physical-chemical parameters and potential
b) Thermal load demands for space heating for each end-user of geothermal sources:

- Dwellings,
- Geothermal SPA,
- Greenhouses,
- Geothermal pools, etc.,
-. Aquaculture,
- Mineral waters production
- Extraction of the micro-elements and natural salts

b) Energy balance between different end-users,
c) Technologies to be applied
d) Preliminary design of the geothermal energy exploitation system
e) Definition of thermal demands
i) Energy conservation, and
k) Economic evaluation of thermal energy (space heating and hot water production installation cost, life cycle, energy product cost, pay back period). This evaluation will be based on actual market prices for equipment, construction etc.

Based on the above analysis, for the best area selected, a Feasibility Study will be performed to analyze three components: energy supply, environmental impact and financial aspects, and to suggest the best solution of the innovative geothermal energy utilization technology applications in that area.

4.3. Environmental protection and preserving level will be improved, to well assist the echo-system protection of thermal and mineral water source areas.

Among other subjects this phase will focus mainly on:

-Examination of the nature of the geothermal fluid
-Environmental impact of the geothermal fluids during their utilization and disposition
- Selection of the most acceptable environmentally methods for the disposal of the geothermal fluids

4.4. The concrete detailed design for the implementation phase of the Project will be prepared.

Task 1. Demonstrative units (pilot plants) will be constructed, monitored and finally demonstrated. These demonstrative units will assist in the promotion of the new innovative technology application facilitating in parallel the transfer of this innovative technology to end users as well as industrial production.

The proposed schemes represent an integrated scheme and cascade scheme for exploitation of geothermal energy. This exploitation will realized by integrated scheme of geothermal energy, heat pumps and solar energy to fulfil. This scheme has an environmental benefit by using renewable energies (geothermal energy, solar energy), new technologies (heat pumps) and energy savings (cascade scheme).

Cascade scheme should be used to fulfil the thermal energy demand for the selected area in order to get the maximum benefit from geothermal energy and the minimum energy supply from heat pumps: the promotion of energy savings will be in place.

These demonstrative units will make researcher and scientists aware, on-site, of specific plant operational problems, new technology implementation problems and finally assist to their in situ solution.

These pilot demonstrative units will help potential users overcome psychological barriers towards the utilization of new innovative technologies for direct application.

Task 2: A promotion and tourist agency will be organized. This agency will prepare the reclaims and booking of the rooms for Albanian and foreign patients.

5. APPLICATION AND TRANSFER TECHNOLOGY FOR A COMPLEX AND CASCADE EXPLOITATION OF GEOTHERMAL ENERGY

5.1. Construction of thermal supply installations:

3. Installation of pipe – distribution system
4. Heat exchanger
4. Distributors
5. Control Room-Monitoring.

5.2. Construction of the experimental units for exploitation of the geothermal energy:

7. Building of SPA, with 30-40 beds, for the medical treatment (gynecological and rheumatic diseases),
8. Construction of heating installation in the buildings
9. Construction of the greenhouse for the flower.
10. Construction of the greenhouse for the legumes.
11. Construction of thermal pool for tourists, wardrobe and bar.
12. Installation of equipment for extraction microelements and natural salts.

5.2. Feasibility Study

Technical and financial feasibility study for innovative geothermal energy utilization technology applications. Market penetration of geothermal energy.

Economic evaluation should include:

- First investments for the proposed schemes (integrated scheme, cascade scheme);

• Evaluation of thermal energy (space heating and hot water production) unit cost produced by integrated scheme: geothermal energy, heat pumps and solar energy;

• Evaluation of benefits (in financial terms) through comparison with the classical scheme of the proposed integrated and cascades scheme;

• Other benefits will be assessed for example the environmental benefit by using renewable energies (geothermal energy, solar energy), new technologies (heat pumps) and energy savings (cascade scheme).

Among others and for one of the two application cases this phase will be examine:

-Preliminary consideration for each case
-Definition of the main parameters affecting each system
-Analysis of the effect of the different parameters
-Selection of the "basic" application cases/techniques
-Design of the system
-Selection of alternative cases
-Final technical conclusions

Based on the above analysis, for the best area selected, a Feasibility Study will be performed to analyze three components: energy supply, environmental impact and financial aspects, and to suggest the best solution of the innovative geothermal energy utilization technology applications in that area.

6. PRELIMINARY COST FOR THE INVESTMENT

Cost estimation is carried out only for the first phases, to realize investment step by step:

No	**Object**	**Cost, in USD**
1	Reconstruction of heating and thermal baths	50 000
2	Construction of two thermal water unit equipment's	80 000
	Construction of green houses, 2 * surface 3 000 m^2	240 000
4	Construction of new SPA Clinic and for new hotel building), (****)	2 200 000
5	Feasibility study and project idea	53 000
9	Other Expenditures	20 000
10	Overhead rate	15 000
	TOTAL exc. VAT	2 418 000

7. ECONOMICAL-FINANCIAL EVALUATIONS

HOTEL-SPA, First Phase: 25 bed rooms, 40 beds.

Currency: USD Inflation rate: 3.5%

Table 1

Economic bases	Years				
	1st	2nd	3rd	4th	5th
8. Number of rooms (1)	25	25	25	25	25
9. Number of beds	40	40	40	40	40
10. Days of operation	280	280	280	290	290
11. Food&beverages-facilities	280	280	280	290	290
12. Guest structure and room price					
13. Average room occupancy	100%	100%	100%	100%	100%
14. Average room price					
	72	74	75	75	75
	50	50	55	55	60

2) Hotel has 15 doubles rooms and 10 single rooms
Rata: Single room 50 USD; Double room 70 USD (Include VAT) (Present room's rate in *** Hotels in Tirana)

Supplementary facilities:

8. Outdoor-indoor thermal & swimming pool
9. Ball sports (tennis, volleyball, basketball)
10. Recreation (sauna, Turkish bath, solarium)
11. Fitness Center with aerobic
12. Restaurant, bar
13. Meeting room
14. Others (rent a car, coiffeur, boutiques)

Table 2
FINANCIAL BASES

Proceeds	%	Years				
		1st	2nd	3rd	4th	5th
1. **Room Rental**	71					
(without breakfast)						
number of rooms		25	25	25	25	25
*day of operation		280	280	280	290	290
=max. room overnight		7 000	7 000	7 000	7 250	7 250
*average room occupancy		72%	74%	75%	75%	75%
=number of room overnight		5 040	5 180	5 250	5 438	5438
*average room price		50	50	55	55	60
=**arrangement** (without f&b)		252 000	259 000	288 750	299 090	326 280
2.**Food&beverage**	26					
a) Full Pension		100%	100%	100%	100%	100%
Number of consumptions		7 056	7 252	7 350	7 612	7 612
*Proceeds/guest		10	10	11	11	12
=full pension		70 560	72 520	80 850	80 850	80 850
b)Beverages		21 168	21 756	22 050	22 836	22 836
-full pension (full pens. * 3)						
Total revenues F&B		91 728	94 276	102 900	106 568	114 180
2.**Food&beverage**	26					
b) Full Pension		100%	100%	100%	100%	100%
Number of consumptions		7 056	7 252	7 350	7 612	7 612
*Proceeds/guest		10	10	11	11	12
=full pension		70 560	72 520	80 850	80 850	80 850
b)Beverages		21 168	21 756	22 050	22 836	22 836
-full pension (full pens. * 3)						
Total revenues F&B		91 728	94 276	102 900	106 568	114 180
3. Telephone revenues	3	10 311	10 560	11 750	12 170	13 214
4. Shopping revenues						
5. Other revenues for rental						
TOTAL REVENUES		**354 040**	**363 874**	**403 399**	**417 828**	**458 674**
OPERATING EXPENSES						
1.Personnel Expenses	28.1	37	37	37	37	37
number of employed						
Year’s salary per employed		1 440	1 4040	1 560	1 560	1 620
Personnel Salary		36 000	36 000	39 000	39 000	40 500
Insurance		13 500	13 500	14 625	14 625	15 187
Personnel Expenses		67 500	67 500	72 345	72 345	75 127
2. **Cost of goods sold**	19.1	45 864	47 138	51 450	53 284	57 090
3. F&B for the personnel (3 USD/day)	13	31 500	31 500	32 625	32 625	32 625
4. Direct expenses Phone+fax; laundry+cleaning	3	7 080	7 277	8 068	8 356	9 073
5. Indirect Expenses - energy, water	11.9					

- Maintenance - Small wares - Travel expenses - Insurance - Advertising - Marketing+Management - Office material - Bensol - Transport ***TOTAL***		28 677	29 474	32 675	33 844	37 152
VAT, 20%		59 511	61 164	67 969	70 402	77 565
TOTAL OPERATING EXPENSES		**240 132**	**244 053**	**265 132**	**270 856**	**288 632**
GROSS OPERATING PROFIT		**113 908**	**119 821**	**138 267**	**146 972**	**170 042**

Table 3
REPAYMENT OF THE CREDIT

Moderate credit 1 300 000 USD
Interest: 3%
Repayment period 15 years

Financial bases	Years				
	1st	2nd	3rd	4th	5th
GROSS OPERATING PROFIT	113 908	119 821	138 267	146 972	170 042
Interest			39 000	39 000	39 000
Credit repayment	101 908	104 821	83 095	89 972	112 042
Cumulating credit repayment	101 908	206 729	289 824	379 796	491 838
Cash flow	12 000	15 000	17 300	18 000	19 000

Financial bases	Years				
	6th	7th	8th	9th	10th
GROSS OPERATING PROFIT	170 042	170 042	170 042	170 042	170 042
Interest	39 000	39 000	39 000	39 000	39 000
Credit repayment	112 042	112 042	112 042	112 042	112 042
Cumulating credit repayment	603 880	715 922	827 964	940 006	1 052 048
Cash flow	19 000	19 000	19 000	19 000	19 000

Financial bases	Years				
	11th	12th	13th	14th	15th
GROSS OPERATING PROFIT	170 042	170 042	170 042	170 042	170 042
Interest	39 000	39 000	39 000		
Credit repayment	112 042	112 042	23 868		
Cumulating credit repayment	1 164 090	1 276 132	1 300 000		
Cash flow	19 000	19 000	19 000	170 042	170 042

payback is 13 years for one hotel-SPA for first their phase, 40 beds (25 rooms), for one moderate credit of 1 300 000 US.

8. GATHERING INFORMATION MATERIAL AND KNOWLEDGE DISSEMINATION IT IS VERY IMPORTANT ELEMENT OF UTILIZATION OF GEOTHERMAL ENERGY

Task 1

Information material concerning the general principles of geothermal application and new technologies will be gathered and created. An information booklet and posters will be published and distributed to possible users.

Task 2. Establishment of communication channels with local users

Communication with local authorities will take place in order to find the end users, especially those capable of installing geothermal applications. Direct personal contacts with end users will also take place.

The investigators will implement this study by answering and focusing on the solution of the following questions:

The selection of the most suitable utilization plan according to the actual applications of the new technologies in question, the energy conservation, the desired transfer of the innovative technology to country, the probable users intentions and the existing heating consumption needs of the planned innovative applications.

The investigation of any probable environmental impact and the selection of the most suitable method for the disposal of the geothermal fluids to avoid possible environmental problems.

The selection of the best possible network for the geothermal fluid transport to ensure the violability of the utilization carrier, a single disposition price and the disposition of considerable quantities of energy (converted in TOE-s).

Task 3.
-To creates ready for use permanent educational and informative structures.
-To provide a useful tool for the education and information of geothermal energy end users

- For further dissemination of the results of this projects will organize days of open conferences. Workshops, seminars, TV and radio-emissions, pamphlets, posters, and summer school will organize. .In parallel, the strategies presented for the geothermal energy exploitation will be announced and criticized during these activities. The participant will originate from the public sector, user's, associations, Technical Chambers, higher educational institutes etc. Finally, material from Phase C will be also forwarded to the public authorities that are responsible for the awareness of users and therefore in close contact with them.

-To introduce, via an attractive method, the concepts of geothermal energy utilization and new technology transfer in the third level education

9. SIGNIFICANCE OF THE PROJECT PROPOSAL AND ITS EXPECTED ACHIEVEMENTS

The project proposal has great importance for Albania:

Firstly, it creates the scientific knowledge base for evaluation of natural wealth of geothermal energy and mineral waters in Albania. These data will be used to evaluate and select the rich areas in country. In these areas it is possible to start the investment for complex exploitation of geothermal energy and mineral water resources

Secondly, transfer of new methods for R&D and evaluation of geothermal water resources, modern technologies and unit equipment for thermal waters exploitation in Albania.

Thirdly, a technical and organizing base for modern hotel SPA construction will be created.

Thermal and mineral water springs, usually, are located in coastal or very beautiful mountainous regions of the Albania. The tourism will be developed. Thermal waters of low enthalpy will be used for the heating of green houses and SPA hotels and tourist villages near the springs. Extraction of chemical micro- elements as Iodine, Bromine, Borax, various natural salts from thermal and mineral waters, CO_2 and H_2S gas, will be achieved by installing the necessary equipment. Drinking-mineral water installations will be constructed. This development will create

new working posts and will ameliorate the life conditions and level for habitants in thermal and mineral water spring areas.

Fourthly, new modern studying technologies will be disseminated in scientific and business community of country.

Fifthly, Environmental protection and preserving level will be improved, to well assist the echo-system protection of thermal and mineral water source areas.

10 .WORK PROGRAMME

Methodology

This project must be implemented during the 3 years period, by the integration of the following phases:

FIRST PHASE.

The project must be realized using a complex of modern methods according to the objectives:

1. Complex and integrated study of all geothermal data on resources of geothermal energy in Albania:

- Integrated geothermal, hydrogeological, hydrochemical surveys in the sources and wells of geothermal energy.

- Mathematical modeling for calculation of potential of geothermal energy in Albania, as well as for the study of reservoirs.

· Geothermal and mineral water resources detailed feasibility study will be carried out in geothermal area. Project idea will be compiled, too.

· Technical projects will be compiled for investments in more perspective areas.

6 months

SECOND PHASE. 1. Construction of thermal water unit equipment in geothermal springs and wells.
2. Heating system, the thermal water unit equipment and baths must be reconstructed in existing Hotels SPA. After second phase, all year SPA frequenting will realize. During the winter there are more demands for the medical treatment.
Good conditions in the SPA will help to have patient numbers increasing.

2. Green house, up to 3000 m^2 surface, must be constructed in the territory of thermal springs and wells

THIRTY PHASE: New Hotels-Clinic SPA hotel construction of (****) in geothermal areas. For the first time, the SPA Clinic and the hotel will have two or three floors, with the possibilities to build and 2 or three other floors in the future. In the ground floor will be located the restaurant, bar, medical clinic and thermal baths. Bedrooms will be located in the first and second floors. Thermal swimming pool will construct in the ground floor or in the yard.

24 months

FOUR PHASE: 1. Unit equipment for the extraction of chemical microelements and salts, CO_2 and H_2S gas will be designed and installed.

2. Unit equipment and collector for treatment and clearing the thermal water before their outflow will be designed and installed, to protect echo-system of the area.

3. Promotion and tourist agency will be organized. Put in full efficiency of all complex of the SPA will be completed.

10 months

11. CONCLUSIONS

In Albania, there are several geothermal energy sources that can be used.
Such geothermal energy sources are natural thermal water springs and deep wells with a temperature of up to 65.5°C. Deep abandoned oil wells can be used as "Vertical Earth Heat Probe".
The integrated and cascade use of geothermal energy in the Albania must start as soon as

possible, in the framework of a joint or separate project.

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DIPOLE – DIPOLE ARRAY CONFIGURATION IN THE FRAMEWORK OF THE RECIPROCITY PRINCIPLE

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Abstract

In the paper it is discussed the change of configuration of IP and resistivity anomalies for dipole-dipole and pole-dipole arrays. The analysis is done based on results of 2D and 3D mathematical modeling carried out successfully in the framework of scientific research of QUANTEC GEOSCIENCE Ltd.,Toronto, Ontario, Canada, and of physical modeling done in the Geophysical Laboratory "Ligor Lubonja" of the Faculty of Geology and Mining, Polytechnic University of Tirana.

Key words: dipole-dipole survey configuration, Reciprocity Principle, IP anomaly, Apparent resistivity anomaly.

Introduction

In the practice of electrical prospecting are employed various array configurations. The location of the current and potential electrodes is defined from the geological tasks to be solved. The Dipole – Dipole array is one of the most common arrays in mineral exploration. This is considered a symmetrical array in terms of the principle of reciprocity, so when the current electrodes are respectively switched with potential electrodes the same responses in IP and resistivity values are observed. However, our recent mathematical models indicate some distortions of the reciprocity principle in IP/Resistivity responses with a Dipole – Dipole array. This can lead to inaccurate target location and negative drilling results.

Presentation of Problem

The well-known reciprocity principle stands on the basis of many array configurations in electrical prospecting like Pole - Pole, Dipole - Dipole, Schlumberger, Wenner etc (Keller, G., V. and Frischknecht, F., C.,1970, Zabarovsky A. 1963, I., Frasheri, A., et al. 1985). “According to the theorem of the reciprocity, no changes will be observed in the measured voltage if the role of measuring electrodes and of the current electrodes are interchanges. Reciprocity can be readily confirmed for an electrode array over a homogeneous earth” (Keller, G., V. and Frischknecht, F., C.,1970).

There is another problem for heterogeneous mediums. Zabarovsky, A.I. (1963) shows that if a body A has received an electrical charge Q_A, a body M will have a potential U_M related with the charge Q_A following the equation:

$$U_M = \alpha_{AM} \times Q_A$$

where α_{AM} is a coefficient dependant on the shape of bodies A and M, their reciprocal position and the boundaries of heterogeneity. If the reversed operation would take place, i.e. the body M to receive electrical charges of Q_M then the potential U_A of the body A would be:

$$U_A = \alpha_{MA} \times Q_M$$

" In electrostatic phenomena science it is shown that $\alpha_{AM} = \alpha_{MA}$. If this equality is true, then $Q_M = Q_A$ and as consequence $U_M = U_A$. Translating this result in the language of electrodynamics, one may say that the potential of electrode M created by the effect of the electrode A would be equal to the potential of the electrode A, if the currents would be emitted in ground by the electrode M, with the condition that the product $I * \rho$ remains the same". On this basis he concluded that the principle of reciprocity is valid for heterogeneous mediums as well.

This conclusion is true for some arrays used for electrical surveys of apparent resistivity methods. Four electrodes Schlumberger array AMNB is reciprocal with the array MABN, pole–pole array C_1P_1 is reciprocal with P_1C_1. The pole-dipole array $P_1P_2C_1$ is reciprocal with $C_1C_2P_1$ (Frasheri, A. et al. 1985). But these reciprocities of current and receiving electrodes are not equivalent with the change of positions of couples of electrodes during profiling, in the relation to the heterogeneity. The pole-dipole array $C_1P_2P_1$ is not reciprocal with the $P_1P_2C_1$. The pole–dipole array is known as an asymmetric array. The same is for the dipole-dipole array $C_1C_2P_1P_2$ relative to $P_1P_2C_1C_2$. All this is connected with the well-known fact that pole-dipole and dipole-dipole arrays give asymmetrical anomalies for the apparent resistivity.

These changes are more evident in IP surveys. In several field surveys some asymmetrical responses are observed with a Dipole – Dipole array ($C_1C_2P_1P_2$ versus $P_1P_2C_1C_2$) in both IP and resistivity measurements. To further investigate this phenomenon some mathematical models were carried out with a program of finite element method (Frasheri A. and Frasheri N. 2000).

This analysis was initiated because of the fact that, in daily practices of geoelectrical surveys using dipole-dipole profiling a little attention is shown towards the evaluation of anomaly configuration depending on the position of couples of current and receiving electrodes. In many publications with the results of modeling and of inversion, the position of electrodes on surveying line is not shown (Dey, A., and Morrison, H. F., 1979, Tsourlos, P.I., et al., 1998, Tsourlos, P. I. and Ogilvy, R. D. 1999). This has consequences in the results of interpretation relative to spatial position of exciting bodies.

Mathematical modeling of the IP effect have based on the Bleil formulae [Bleil D., 1953; Seigel H.O., 1959]:

$$U_{IP} = c \times \int_V \nabla U \times \left(\frac{1}{\vec{R}} \right) \times dv \qquad (1)$$

Where: U_{ip} is the IP potential;

$\vec{R}$ is the distance vector from the integration point to the receiving point;

∇U is the potential gradient of the primary electrical field, calculated by solving the finite element model.

To achieve the mathematical modeling and the inversion of IP data, we have used the evaluation of Komarov V.A., which is expressed with the formulae [Komarov V.A., 1972]:

$$C(Uo+Uip) \approx CUo \qquad (2)$$

where: Uo is the potential of the field of primary electrical currents,
Uip is the potential of the field of induced polarization,
C is the IP susceptibility.

Based on mathematical modeling of IP anomal field, there is a formal similarity of the polarizable medium and the increasing of electrical specific resistivity of this medium as proposed by [Komarov V.A., 1972] and used by many other authors (Avdeevic M.M., Fokin A.F., Frasheri A. 1989, Frasheri et al 1994, Frasheri A., Frasheri N. 2000, Hmelevskoj V.K., Shevshin V.A. 1994, Tsourlos P.I., Szymanski J.E., Tsokas G.N., 1998, Tsourlos P.I., Ogilvy R.D., 1999):

$$\gamma^* = \gamma(1\text{-}m) \quad \text{or} \quad \rho^* = \frac{1}{\gamma(1-m)}; \qquad (3)$$

where: γ^*, ρ^* are fictive electrical conductivity and resistivity, considering the polarizability as well,
γ is electrical conductivity
m is IP chargeability

Consequently, induced polarization is considered as linear phenomenon.

For 3D modeling of IP effect from targets with massive texture in homogeneous medium we have transformed the Bleil formulae, using Green's formulae (Frasheri N. 1983, Frasheri A., Frasheri N. 2000):

$$U_{IP} = c \times \int_S \left(\frac{1}{R}\right) \times \left(\frac{dU}{dn}\right) \times ds \qquad (4)$$

Where: R is the distance vector from the integration point to the measurement point;
dU/dn is the gradient of the primary electrical potential on the boundary S of the target.

Ne figuren 1 tregohet rezultati i nje modelimi matematik te PP, te realizuar me anen e metodes se elementeve te fundme, i krahasuar me anomaline e vrojtuar ne terren.

With the same method of finite elements, simultaneously with the IP effect, the apparent resistivity is calculated as well.

Ne fig. 2 jepet krahasimi i anomalise se llagaritur me programin e mesiperm dhe asaj teorike si edhe anomalise se vrojtuar ne modelime fizike. Nga te dy ket raste konstatohet se saktesia e modelimit matematiatik eshte e mire.

Konceptimi i IP si fenomen linear, ka sjelle qw ne modelimet mathematike, IP anomalite e kalkuluara te ndryshojne nga ato te rezistences (fig. 3) Ne keto sections konstatohet se:

- Skaji i siperm i anomalive perputhet mire me skajin e sipert te target e polarizueshem,
- IP Anomaly mbetet e hapur drejt thellesise edhe nen skajin e poshtem te target. Ne ndryshim nga kjo, anomalia e rezistences se dukshme mbyllet nen nivelin e trupit. Te njejtin fenomen ka verejtur edhe Komarov V.A. (1972) ne IP Vertical Sounding.

Numerical results for different models

Figs. 4 and 5 present the mathematical model results of IP and resistivity responses with dipole–dipole profiling. Two anomalies are observed in both parameters. Considering the reference plotting point in between the potential electrodes P_1 and P_2, one of the anomalies is obtained over the prism while the second one at a distance O_1O_2, between the centers of the current and potential dipoles. This presentation is conditioned on the distribution of the electrical field of the dipole - dipole array. Because a mirror image is missing in the center of the profiles, especially for IP, it means that $C_1C_2P_1P_2$ array responses are not equivalent with $P_1P_2C_1C_2$, or in mathematical terms, the principle of reciprocity is not strictly met. Keller, G., V. (1970) also presents the same phenomenon for the apparent resistivity.

In pseudosection presentation, where the plotting point is located at the intersection of lines coming at 45° from midpoints between C_1C_2 and P_1P_2, these anomalies are located in both sides of the prism (Figs. 6, 7, 8, 9). For the resistivity parameter this location is almost symmetrical in shape and amplitude, for the vertical target (Fig. 6). The symmetry is perfect in cases when the thickness of the prism is equal or greater than the dipole spacing “a”, and becomes poor for thinner prisms (Fig. 9).

Alternatively, the IP anomalies are asymmetrical even in cases of vertical prisms (Fig. 6 and 9). In such cases, the epicenter of the most intensive anomaly is displaced on the side of current dipole C_1C_2. For shallow inclined prisms, the epicenters of both IP and resistivity anomalies are displaced on the opposite side of the dip. In cases of deep inclined prisms, the displacement is in the dip direction, providing that this is in the direction of the current electrodes (Fig.3).

The configuration of the IP/Resistivity anomaly is also dependent on the dip angle amplitude, relative to the current electrodes location.
The amplitude and the asymmetry of IP anomaly depend on the orientation of the polarizing vector of the primary field in connection with the prism location. In fig. 10 is presented the electric polarizing field distribution for the gradient array and dipole-dipole array. The great difference between distribution of the electric field in both cases, very well express the changes of the IP anomaly configuration for gradient and dipole-dipole array. In Fig. 11 is presented the changes of the anomaly configuration in the dependence of the location of the target, in relation with the current electrodes.

The same configuration of IP and resistivity anomalies is observed by physical modeling.

Anomalous tableau becomes more complicated when several exciting bodies are located under the surveying line. It is sufficient that the distance between two bodies to be less than 0.5 of their extension in depth, that over these bodies a single anomaly is received, being too wide and with the epicenter over the space between bodies (Fig. 12, 13). Such situation does not permit a correct interpretation of the anomaly during the inversion process. In opposite, in the real section with multiple gradient array, two separate anomalies are observed (Fig. 14).

Asymmetrical IP and resistivity anomalies, in dependence of the location of current and potential dipoles in relation with the target, shows that the lack of orientation in the current and potential electrodes is not always without problems in manual or inversion interpretations of the IP/Resistivity data surveyed with a dipole–dipole array.

Conclusions

1. The anomaly configuration in an IP/Resistivity survey with a dipole–dipole array is dependent on the location of the current and potential electrodes in connection to target. In this regard, logistical information about the survey should include the array orientation (left-array or right-array). The position of the array must be shown in plots and pseudosections. During the profiling, it is necessary to keep the same configuration of current and receiving dipoles.

2. The results of the survey should be interpreted accordingly the array orientation in the survey line, in order to define the placement of exciting bodies, the direction of its inclination and the its depth. The same recommendation is valid for the process of inversion.

3. Profiling with dipole-dipole arrays has smaller discriminative capability for IP surveys, compared with other arrays as the gradient array.

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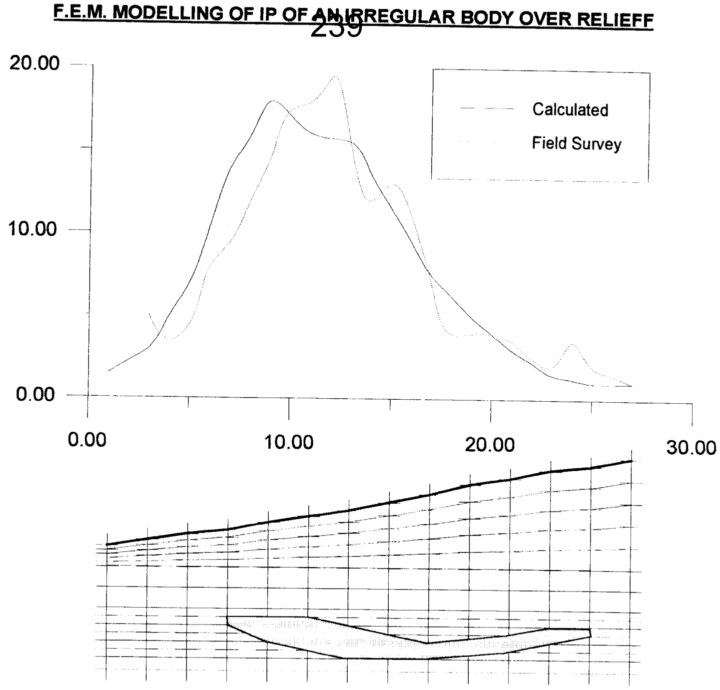

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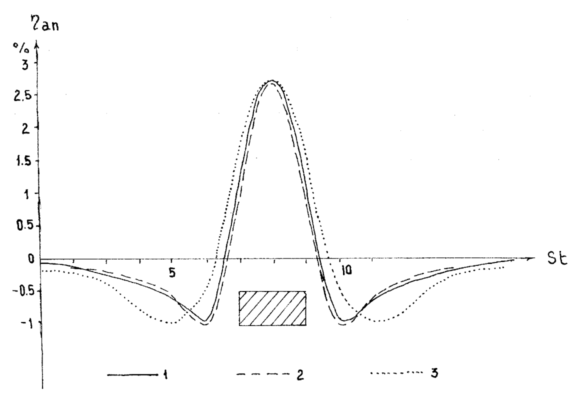

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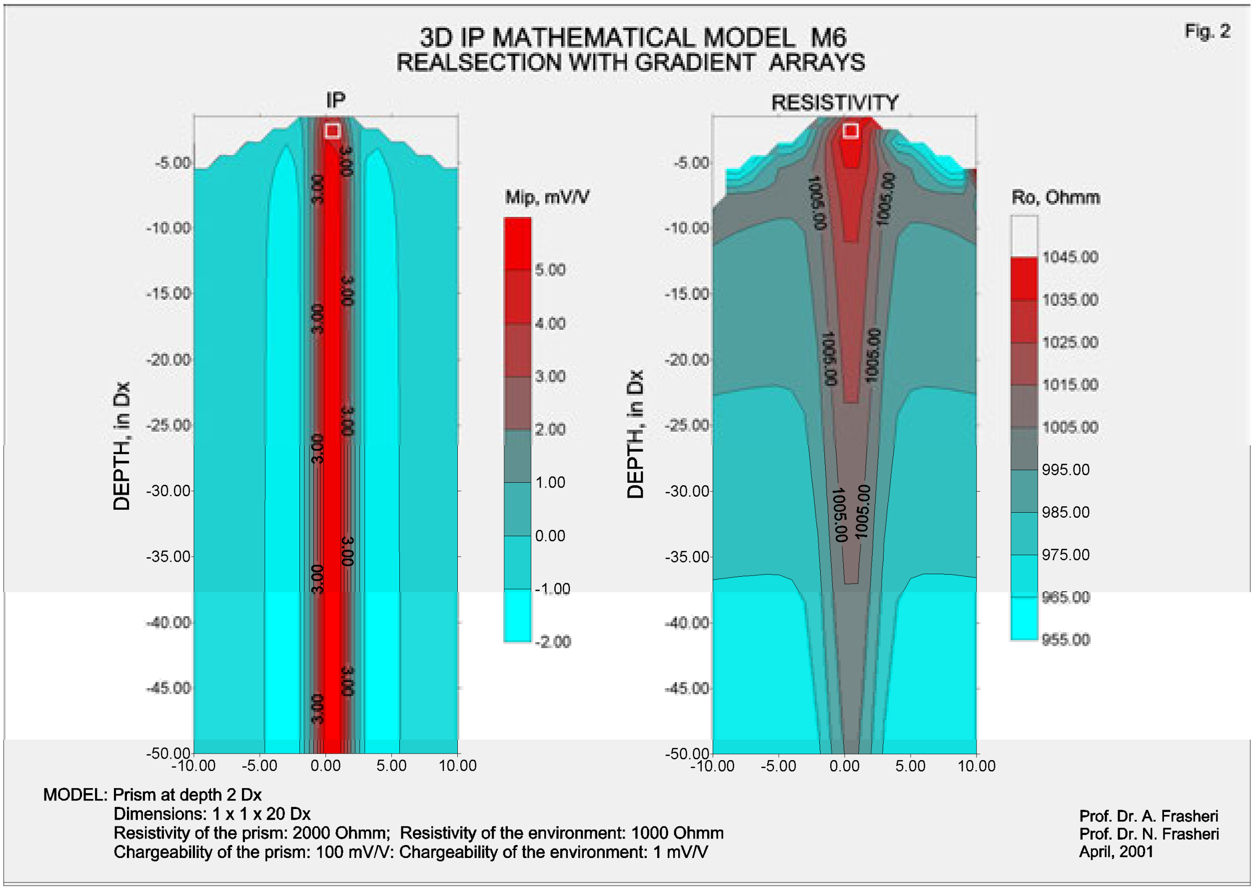

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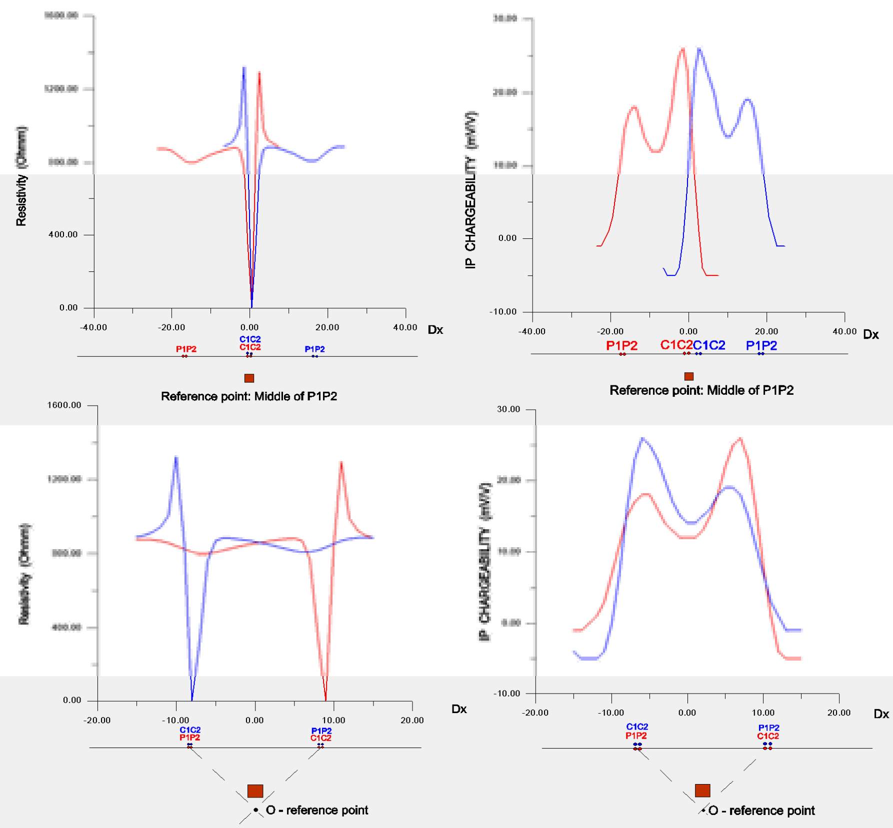

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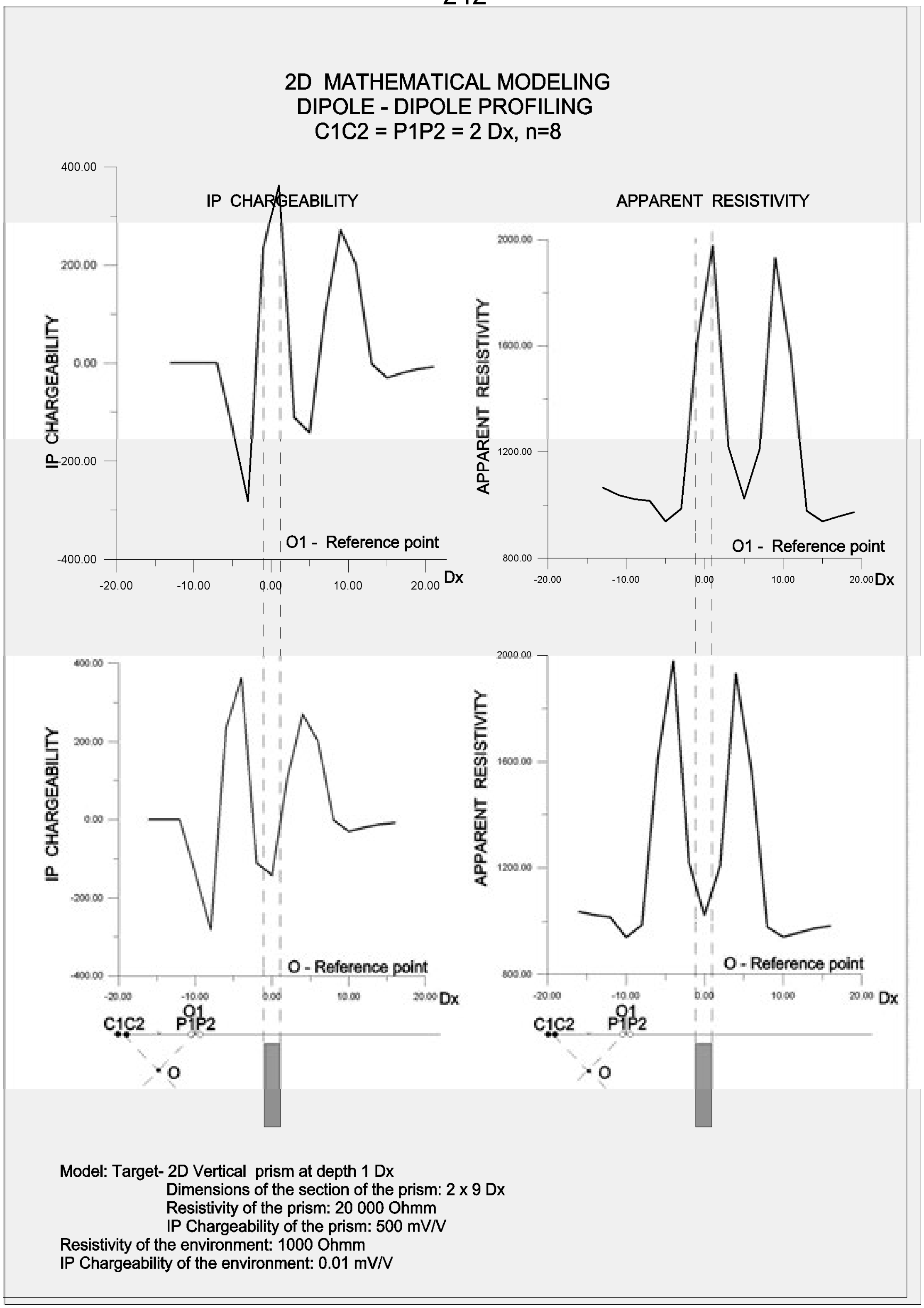

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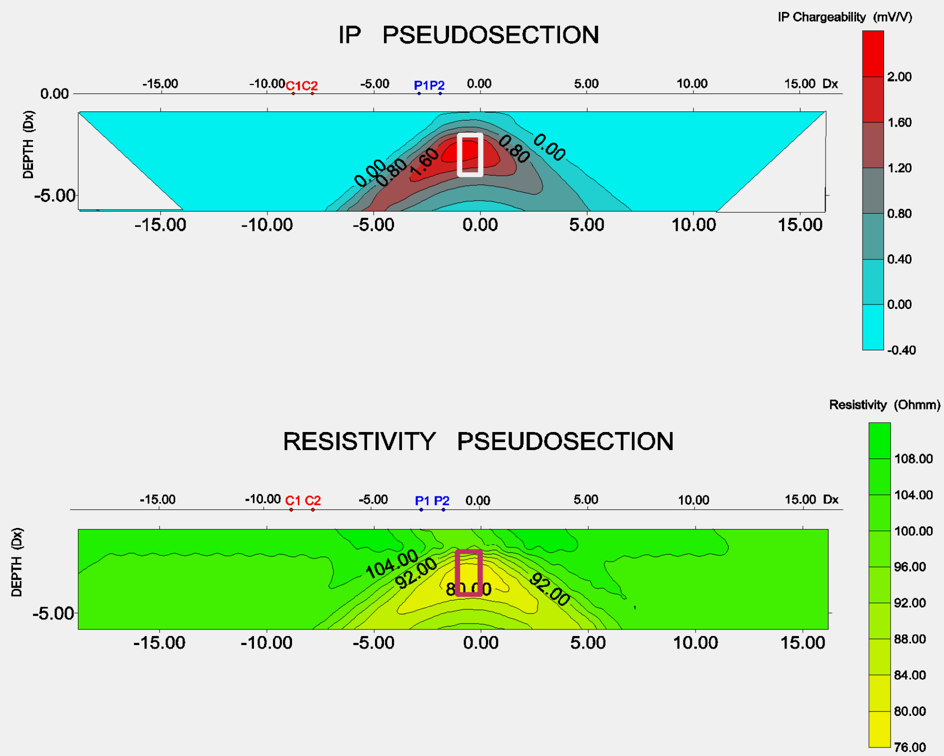

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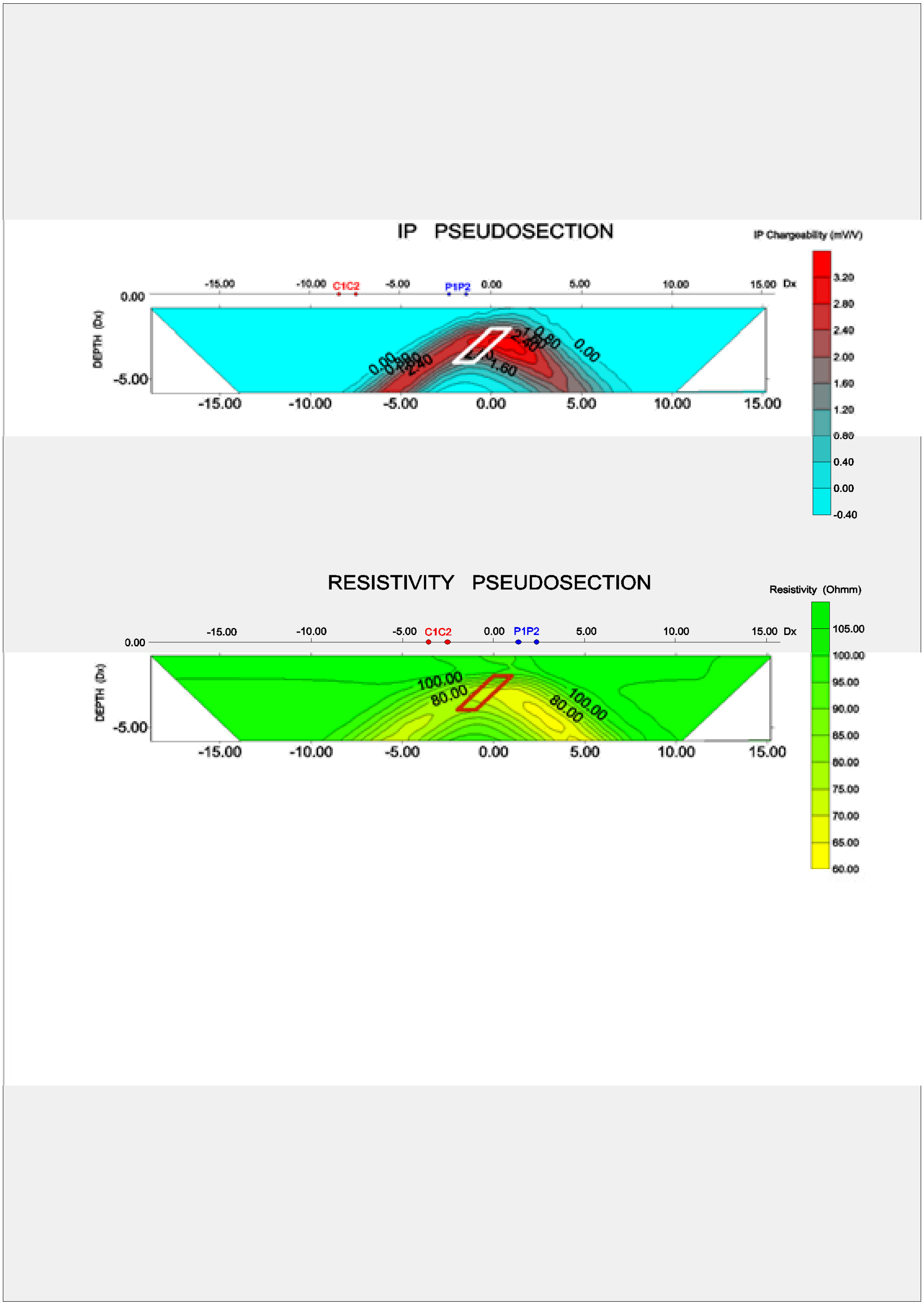

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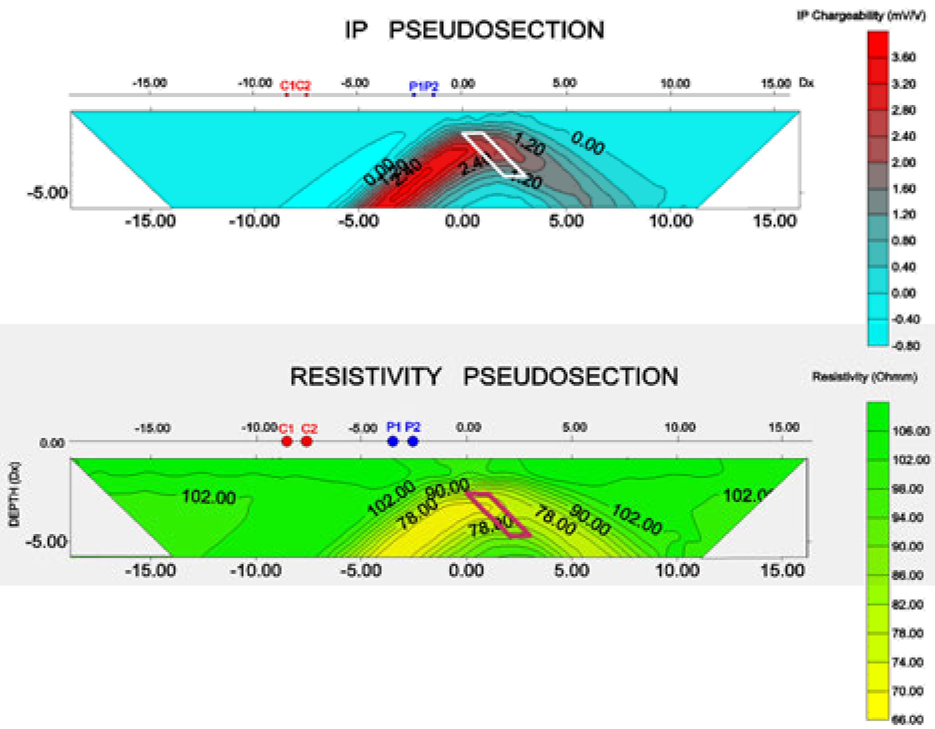

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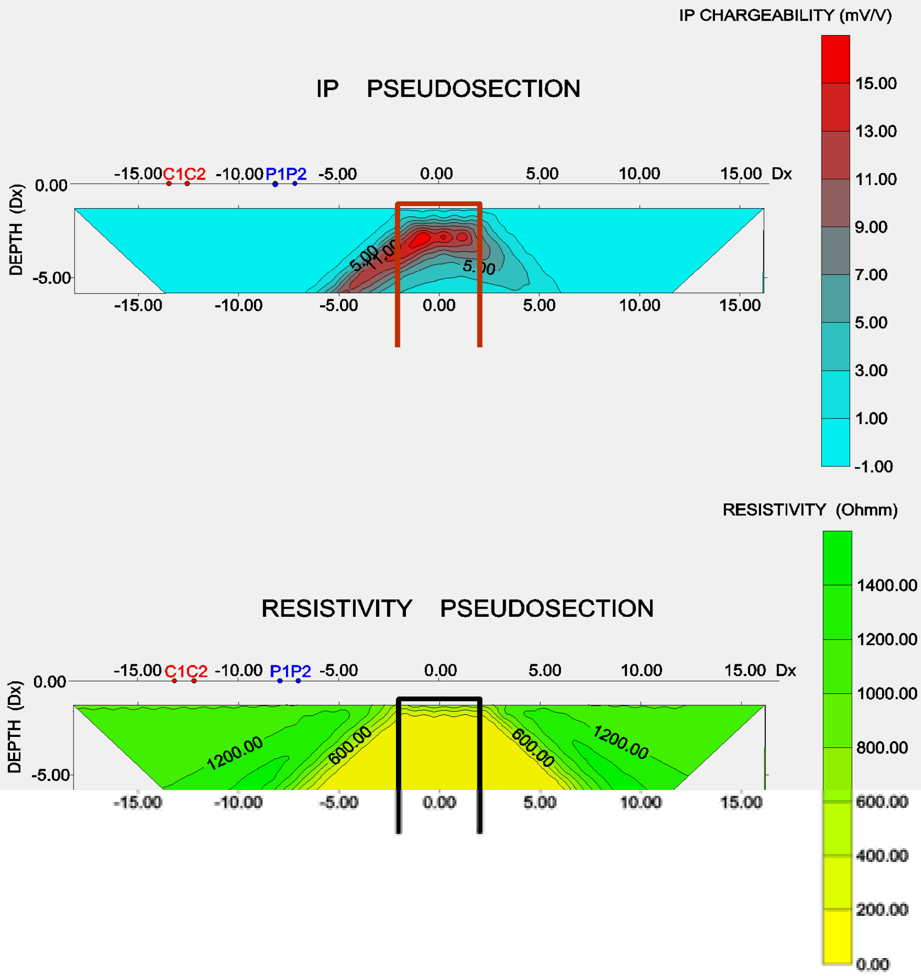

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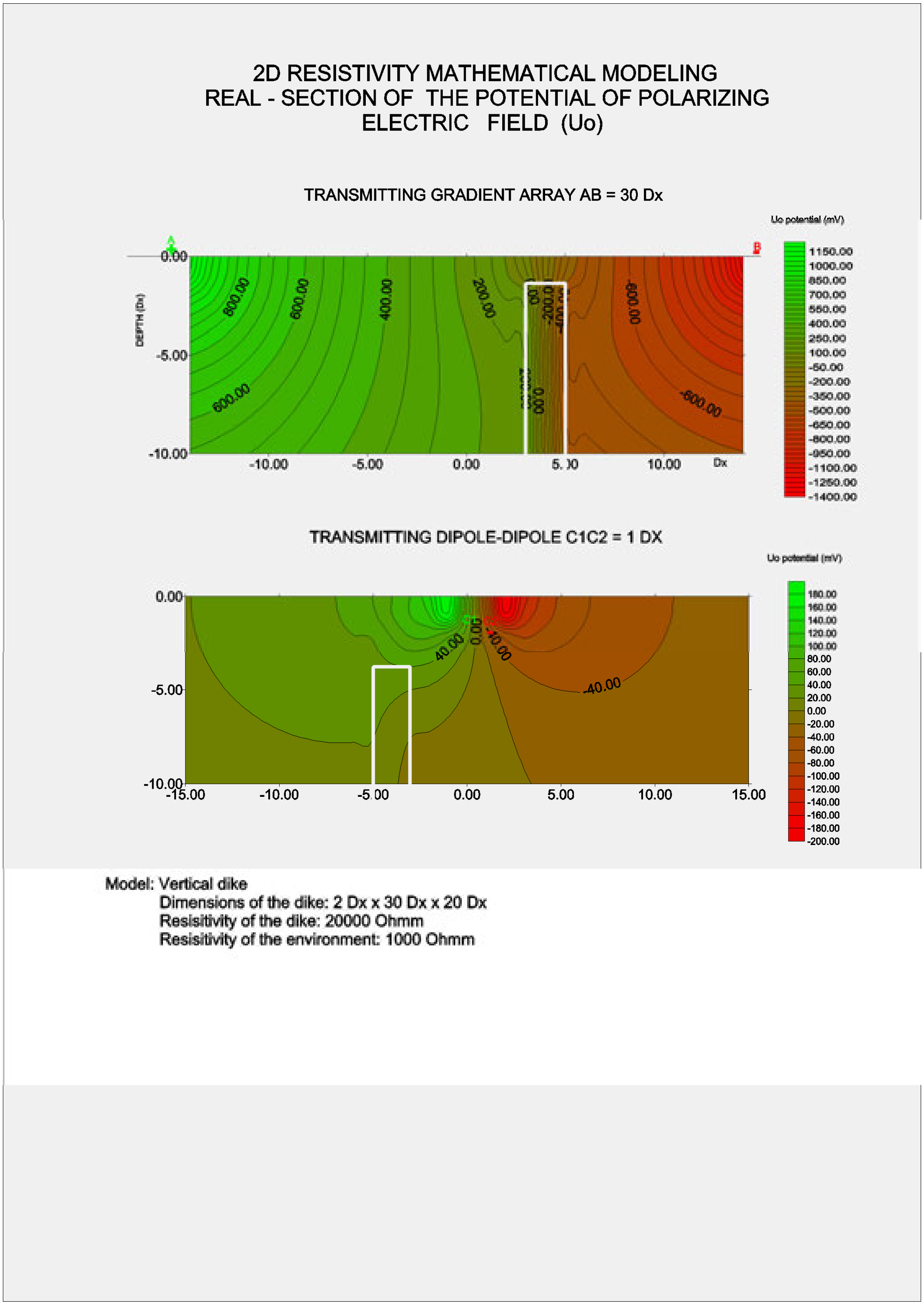

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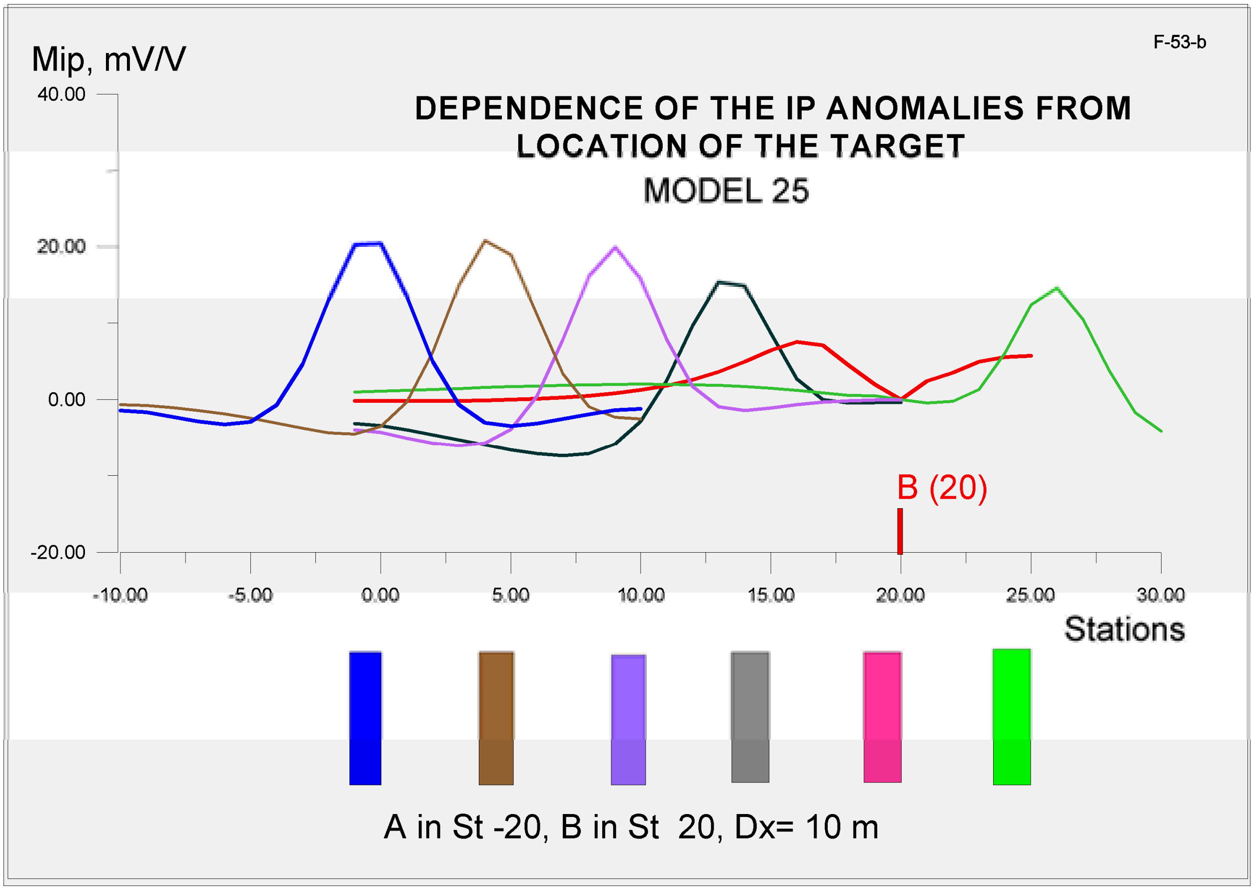

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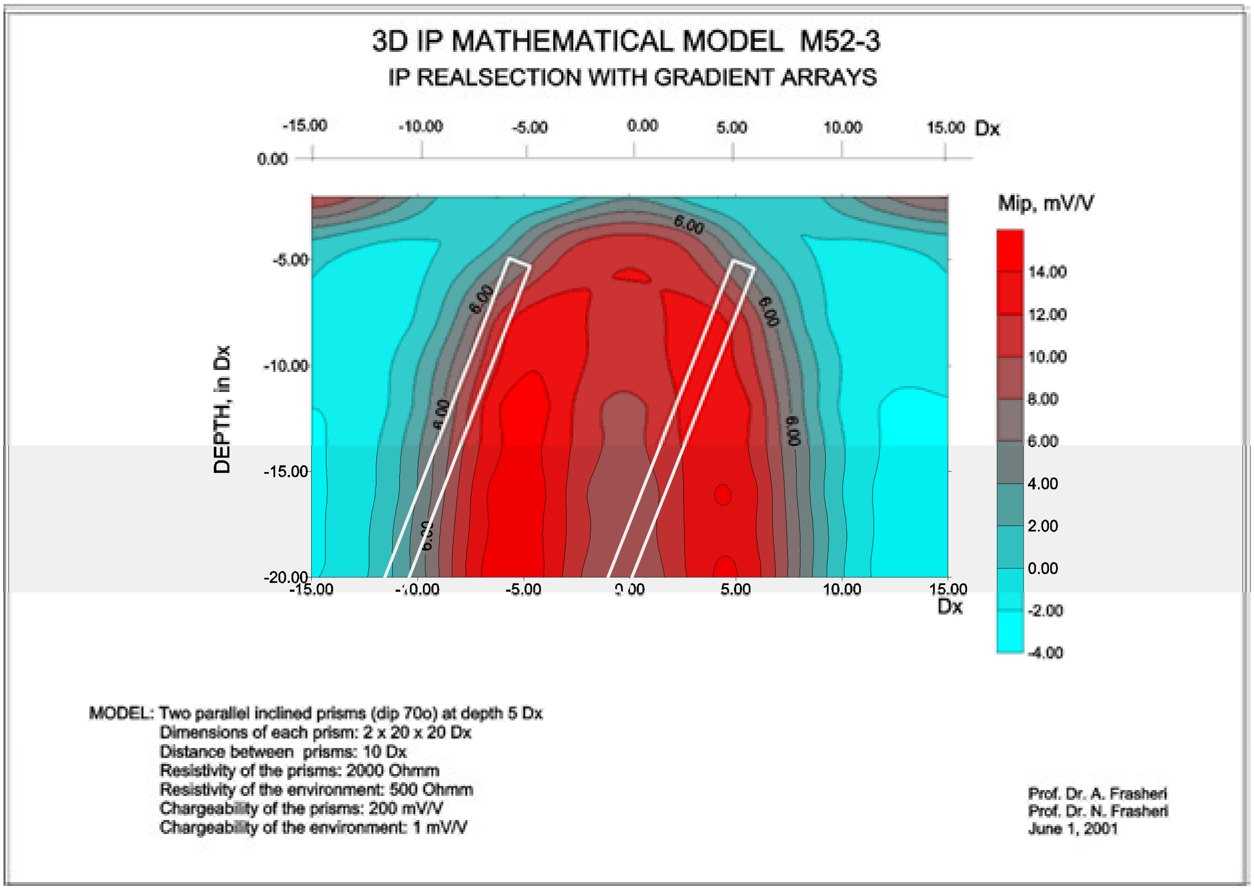

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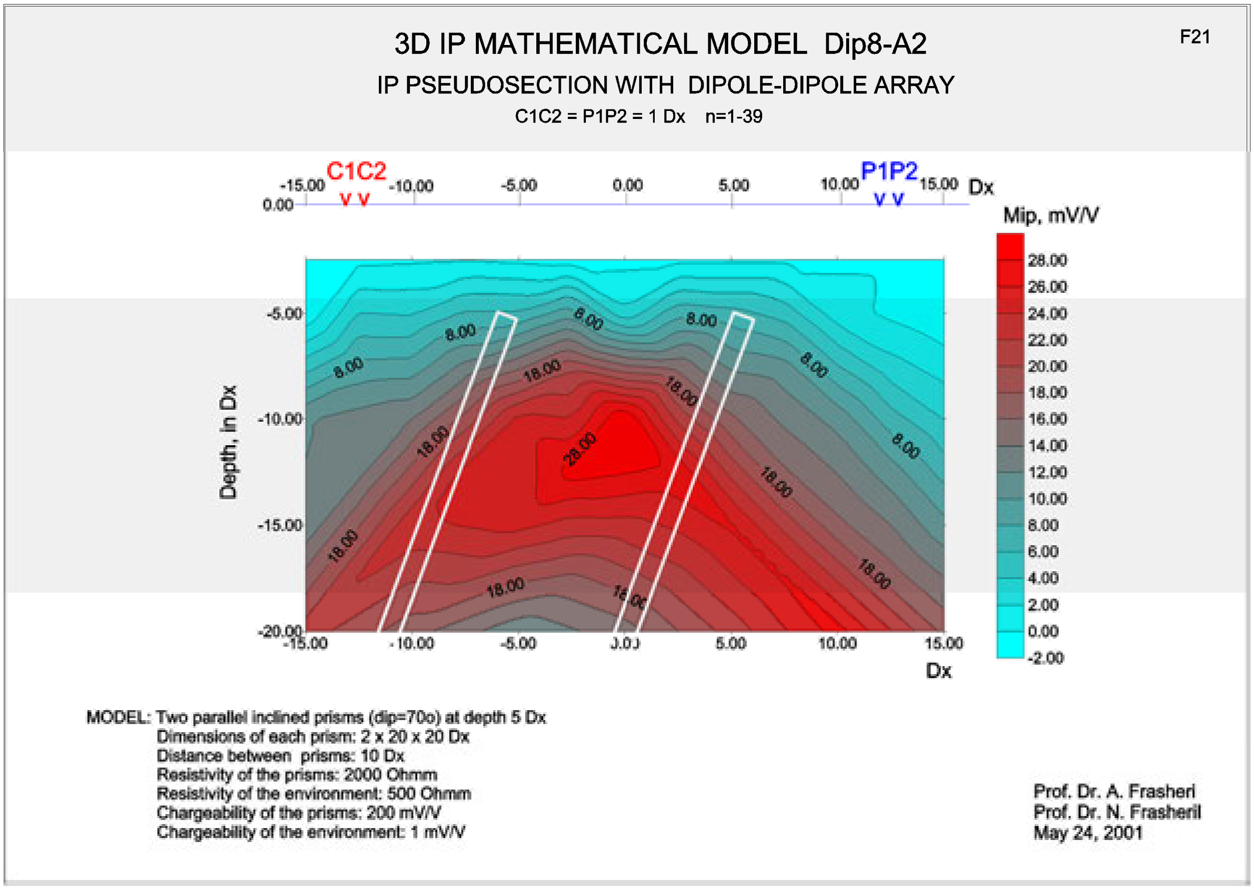

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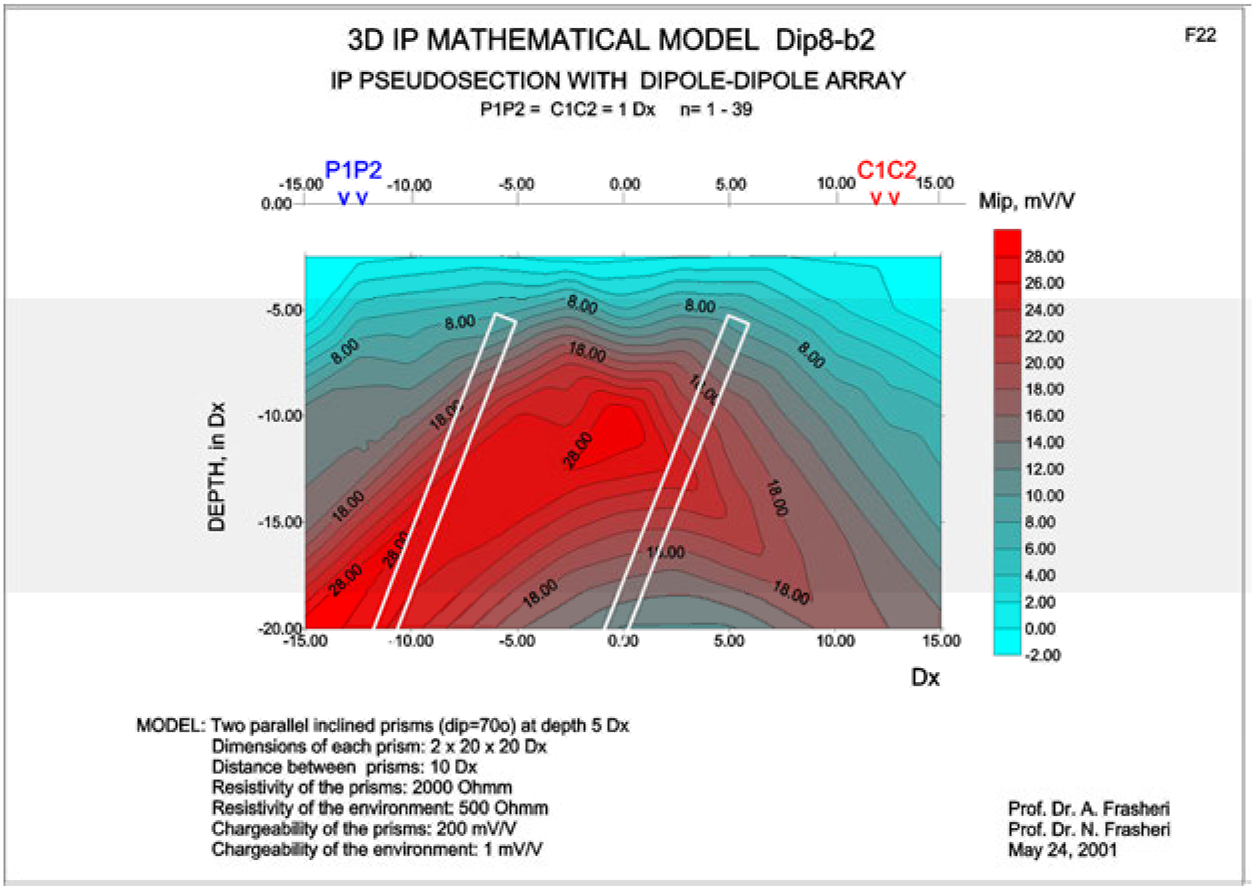

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JOURNAL OF THE BALKAN GEOPHYSICAL SOCIETY, Vol. 5, No 2, May 2002, p. 47-56, 11 figs.

Relations between the hydrocarbon migration chimney and the electric self-potential field

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Abstract: *Survey results for the distribution of self-potential field over the oil reservoirs in Albania are presented. Self-potential surveys have been performed in the framework of the integrated geophysical-geochemical experimental investigation for a direct oil and gas exploration. Relations between self-potential anomalies and hydrocarbon migration chimney are arguments in a particular paragraph. It is observed that hydrocarbon migration chimney has caused a multi-elements geochemical anomaly and integrated geophysical ones. 3D modeling results of the self-potential field distribution in oil reservoir located at different depths are analyzed also.*

Key words: *Direct Hydrocarbon Exploration, Hydrocarbon Migration Chimney, Self-potential Anomalies, Vertical SP gradient.*

METHODS

Electric self-potential field distribution is observed over several oil and gas reservoirs in Albania. These carbonatic and sandstone oil reservoirs are located in different depths, from 900 up to 3500 meters. Geo-electrical observations have been carried out by the surface surveys of the electric self-potential and through analyses of the SP logs in the depth. Mathematical 3D modeling of distribution of electric current over oil reservoirs has been realized.

Migration of the hydrocarbons from their reservoir towards the Earth surface causes changes in the physical and chemical status of the covered reservoir rocks. The rocks of chimney become distinguished from the surrounding rocks located outside of the reservoir contour (Pirson, 1973). Such well-known phenomena have been studied in a number of hydrocarbon reservoirs in Albania (Frasheri *et al*., 1982, Stambuli *et al*., 1983). The main geochemical processes between rocks and hydrocarbon migration flow are the redox reactions. The epigenetic reduction facies of the covered rocks are observed over reservoirs. Consequently for a modeling of the self-potential field distribution, the oxidizing-reducing potential E_h has to be calculated:

$$E_h = E_0 + \frac{RT}{F} \cdot \ln\left(\frac{Fe^{+3}}{Fe^{+2}}\right) \tag{1}$$

where: E_0 - is the potential of a standard system, taken conventionally as $E_0 = 0$; R is the gas universal constant; F is Faraday's number, T is the solution temperature in Kelvin degrees. In parallel we have calculated the reducibility coefficient (Werner 1970):

$$K = \frac{C \cdot Fe^2_{HCl} + Fe^2_{FeS_2}}{\Sigma Fe} \tag{2}$$

where: Fe^2_{HCl} is the content of two valence iron ions abstracted by HCl; $Fe^2_{FeS_2}$ is the content of two-valence iron sulphide; $\Sigma Fe = Fe^{+2}_{HCl} + Fe^{+3}_{HCl} + Fe^{+2}_{FeS_2}$ is the total sum of content of iron ions, two and three valence, which have participated in the chemical reactions; C = 0.236 is a constant.

Figure 1 shows the stratigraphic column and the values of the coefficient K of the rocks over Ballshi oil and gas reservoir in Albania. Results from 130 analyzed samples show that the geochemical epigenetic facies changes from small reduction of the flysch formation in depth, towards the reduced neogenic molasses near the Earth surface. This status changes with an average gradient of –0.021/100 m. The surrounding chimney rocks represents negligible reduced facies, with a vertical gradient of –0.00025/100 m. The oxidizing-reducing potential E_h increases toward the depth with a gradient of 3.6 – 9.6 mV/100 m in the rocks over the reservoir. These changes are determined by following equations:

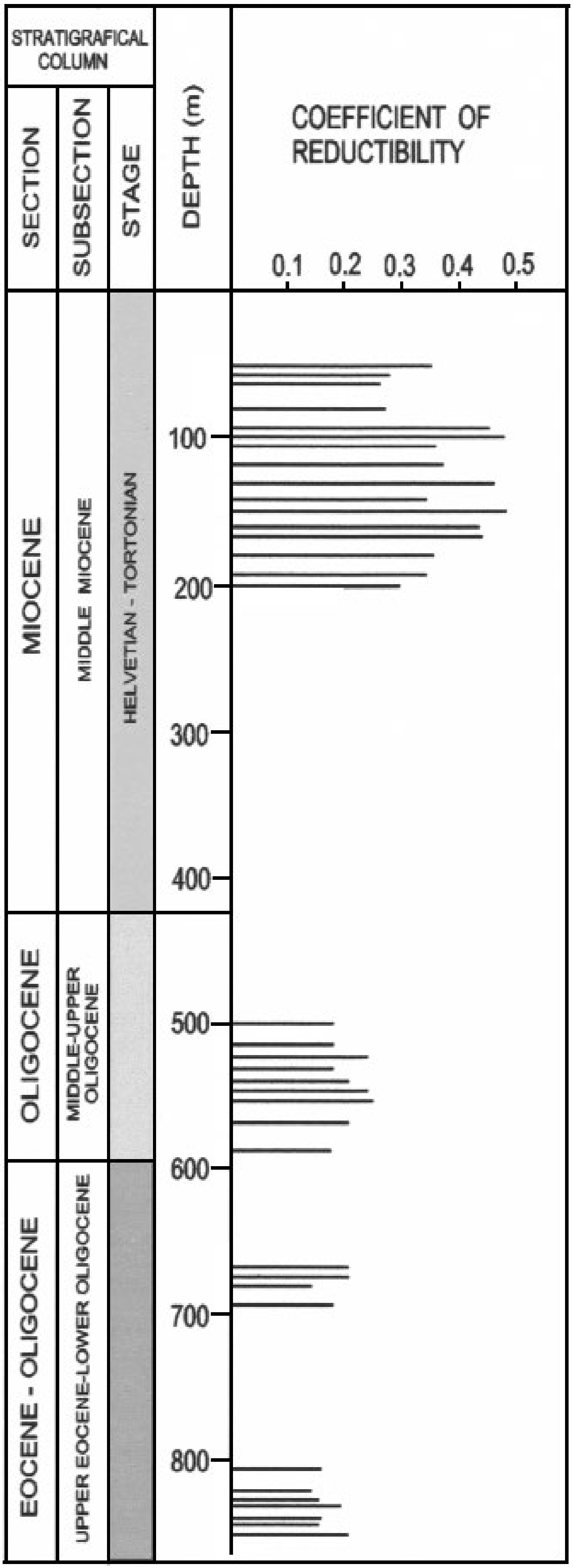


FIG. 1. Summary geochemical column of the reduction coefficient of Ballshi oil and gas reservoir. (After Stambuli Th. *et al*., 1983).

Over the reservoir:

$$K = -0.079H + 0.54 \tag{3}$$

$$E_h = 9.6H - 6.0 \text{ (mV)} \tag{4}$$

In the same formation inside of the chimney:

$$K = 0.00025H + 0.22 \tag{5}$$

$$E_h = 0.01H - 5.88 \text{ (mV)} \tag{6}$$

where: H is the depth of the reservoir from the Earth surface.

The gradients of K and E_h are in dependence on the distance r from the epicenter of the reservoir. They have great values near this epicenter and decreases towards the contour of the reservoir. They are equal to zero outside the contour water/oil. These changes are determined by the equation:

Over the reservoir:

$$E_h = K(Z - H)(a - r) + C \tag{7}$$

Outside the reservoir:

$$E_h = C \tag{8}$$

where: H is the depth of the reservoir; Z is the depth of the survey point, where the potential is calculated, from the epicenter of the reservoir; r is the horizontal distance of this point to the epicenter of the reservoir; a is the radius of the reservoir; C is a constant.

These changes of the oxidizing-reducing status of the chimney and surrounding rocks are the source of the Electro-motor forces with a spatial distribution able to generate stationary electrical currents of the self-potential field in environment. The chimney of oxidizing-reducing system of the rocks over oil reservoir represents the "generator" of the electric currents.

For the theoretical modeling of the self-potential field I have used the following equation:

$$E_{Fem} = -\frac{RT}{F}\cdot\left(\frac{d}{dx}\ln C_{Fe^{+3}} - \frac{d}{dx}\ln C_{Fe^{+2}}\right) = -\frac{dE_h}{dx} \tag{9}$$

The distribution of self-potential voltage have been calculated using the equation of Poisson:

$$\Delta U = f(x,y,z) = \frac{d}{dx}(\gamma E_{Femx}) + \frac{d}{dy}(\gamma E_{Femy}) + \frac{d}{dz}(\gamma E_{Femz}) \tag{10}$$

where: $f(x,y,z)$ expresses the distribution of the Electro-motor force,

$$Fem = -\frac{RT}{F}\cdot\left(\frac{1}{C_{Fe^{+3}}}\cdot\frac{dC_{Fe^{+3}}}{dx} - \frac{1}{C_{Fe^{+2}}}\cdot\frac{dC_{Fe^{+2}}}{dx}\right) \tag{11}$$

where: $C_{Fe^{+2}}, C_{Fe^{+3}}$ are two and three valence iron ions concentration.

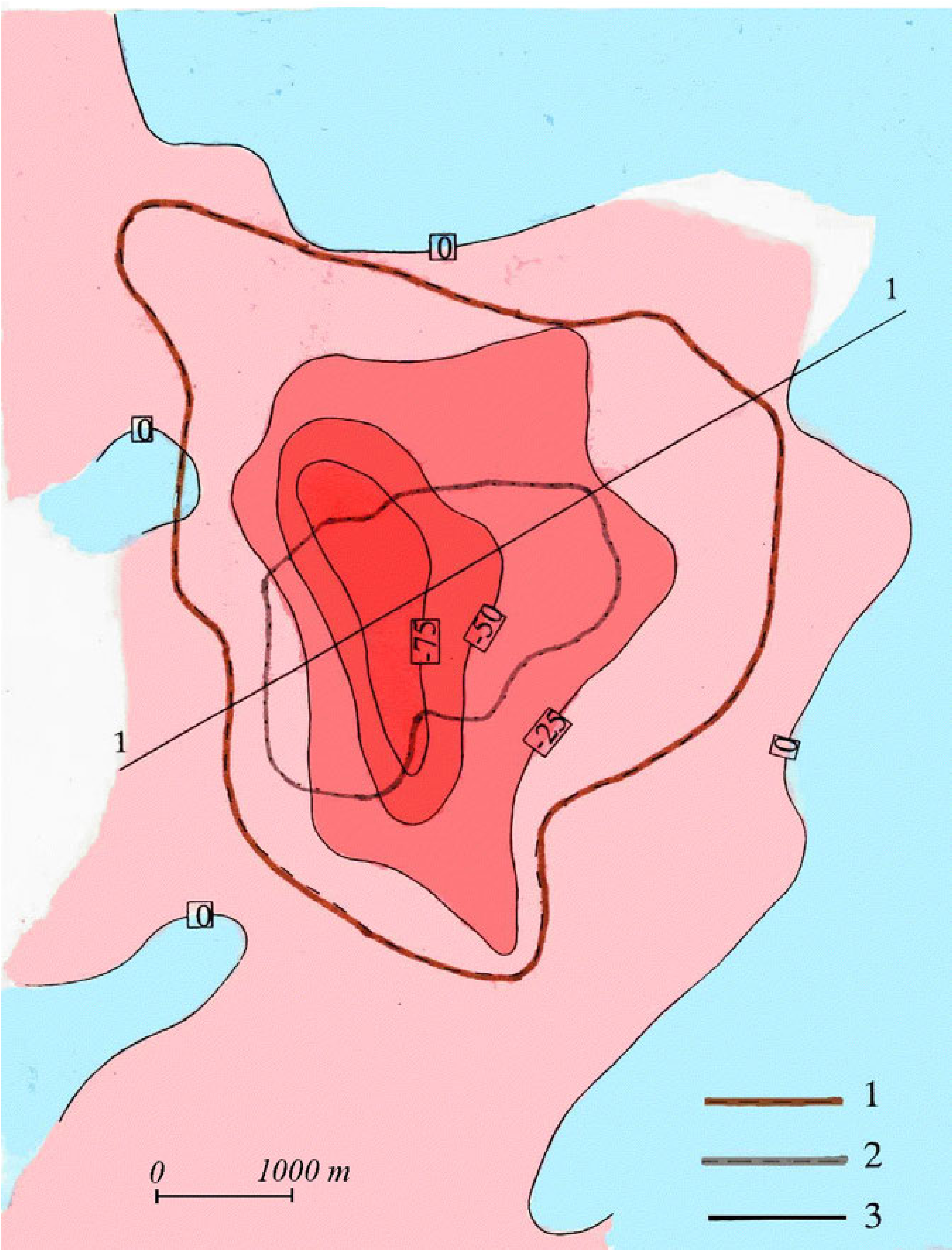


FIG. 2. Self-potential anomaly map, Ballshi oil and gas reservoir, Albania. 1 - The oil-water contour; 2- The oil-gas contour; 3- The potential contours (the contour values are in mV).

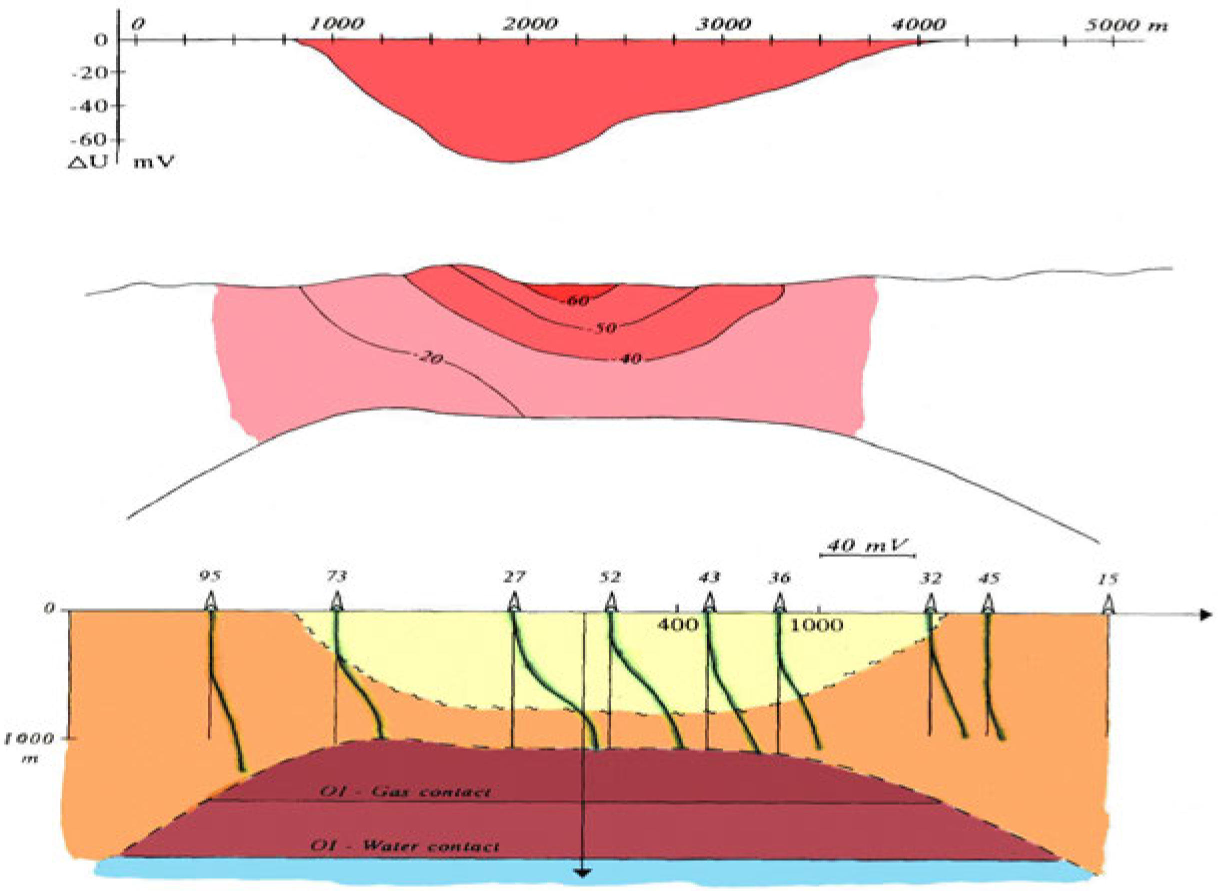


FIG. 3. Geoelectrical section 1-1, Ballshi oil and gas reservoir, Albania. a) Self-potential anomaly observed at Earth surface; b) Mathematical model of the distribution of self-potential in the vertical section; c) Vertical gradient of the "zero line" of SP logs in the wells in Ballshi oil and gas reservoir.

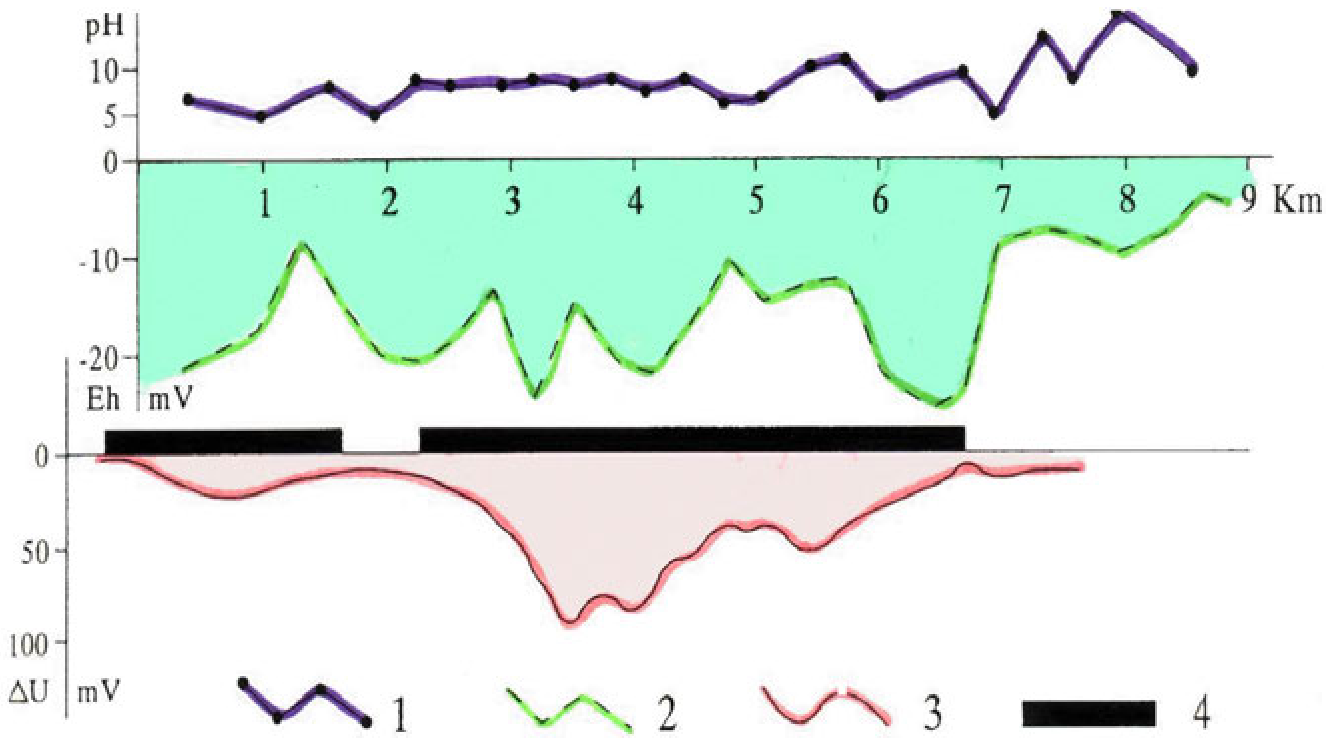
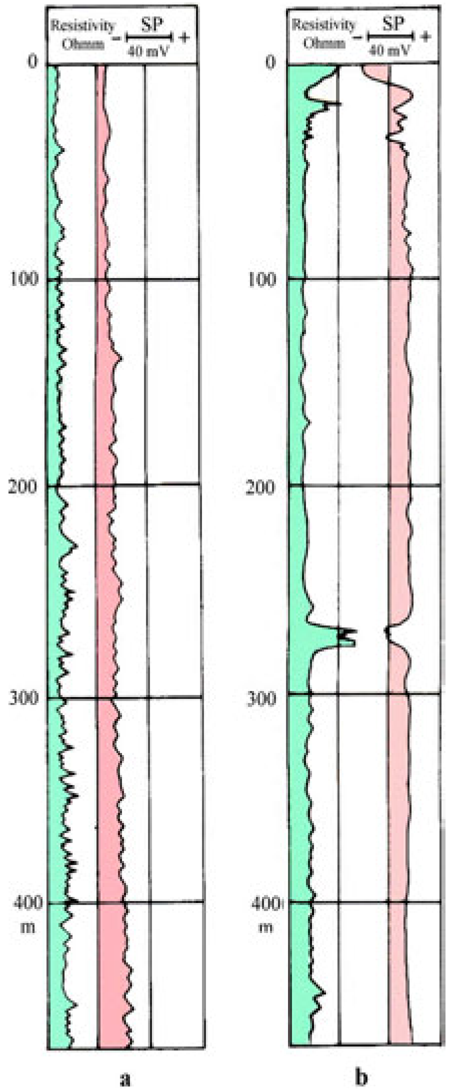


FIG. 4. pH anomaly (1), E_h anomaly (2) and self-potential anomaly (3) in the 1-1 Line, Ballshi oil and gas reservoir.



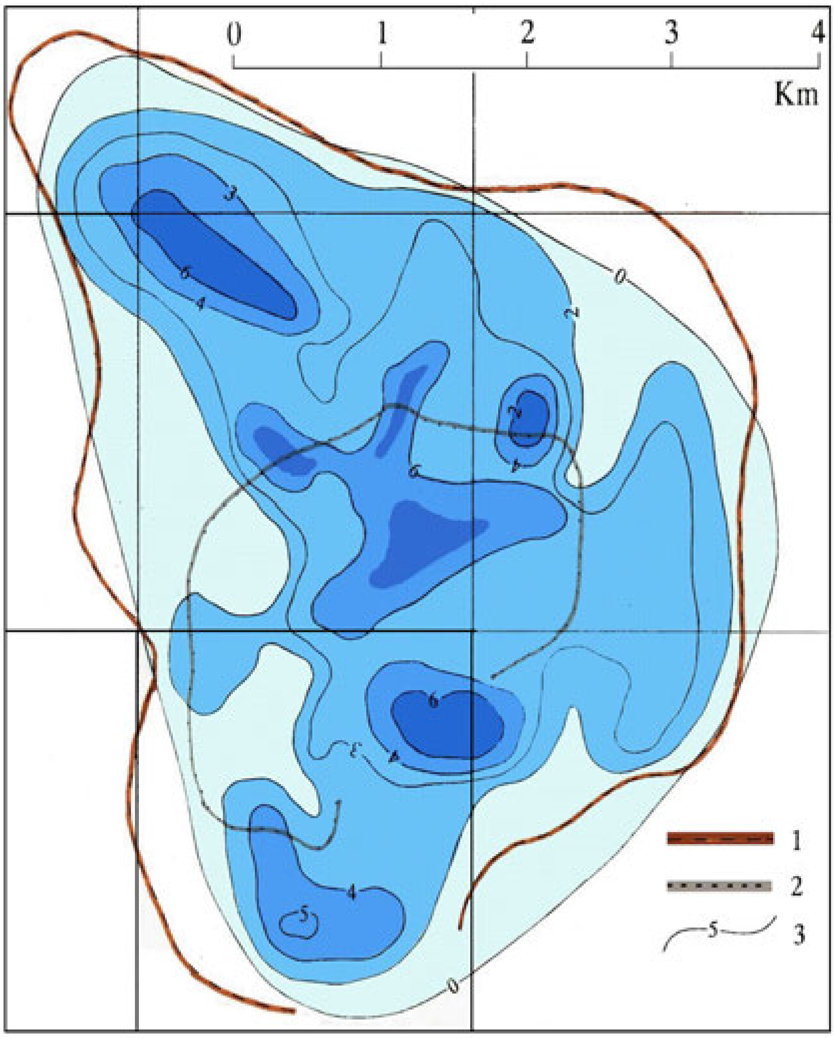


FIG. 5. Trend of the "zero line" of the spontaneous potential logs inside of the reservoir, with a positive vertical gradient from 2 to 15 mV/100 m (a) and outside of the oil-water contour, with a vertical gradient 0 mV/100 m (b)

FIG. 6. Vertical gradient of the Spontaneous Potential (SP) logs in the wells in Ballshi oil and gas reservoir. (The numbers in the contours are average SP vertical gradients in mV/100 m).

The solution of the equation (9) has been found using numerical methods.

DISCUSSION AND ANALYSIS

Self-potential anomalies at Earth surface have been observed in several oil reservoir areas in Albania. These anomalies have amplitudes between 20 up to 100 mV (Fig. 2, 3) (Frasheri, et al., 1981, 1982). Redox potentials E_h in the area of the reservoir have been observed too. These SP are analogues with the anomalies observed in oil reservoir areas in different countries (Czorgei and Lada, 1985; Pirson, 1973).

The presence of E_h anomaly shows that over oil deposits chimney of reduced rocks are located (Fig. 4). Surrounding rocks outside of the reservoir area are oxidable (Frasheri, *et al*., 1981, Stambuli, *et al*., 1983). From 130 analyzed samples from geological section of the oil deposits shown in Figure 1, the conclusion is that the epigenetic geochemical facies changes from weakly reduced flysch rocks in depth towards reduced at the Earth surface, where neogenic molasses are located (Fig. 1). The coefficient of reductibility changes with an average vertical gradient of –0.021/100 m. The oxidizing-reducing potential E_h increases in depth with a vertical gradient of 3.6-9.6 mV/100 m in the rocks over the reservoir.

The self-potential anomalies are extended at depth, too. This fact has been proved through the positive drift at depth of the "zero line" or "clay line" of the Spontaneous

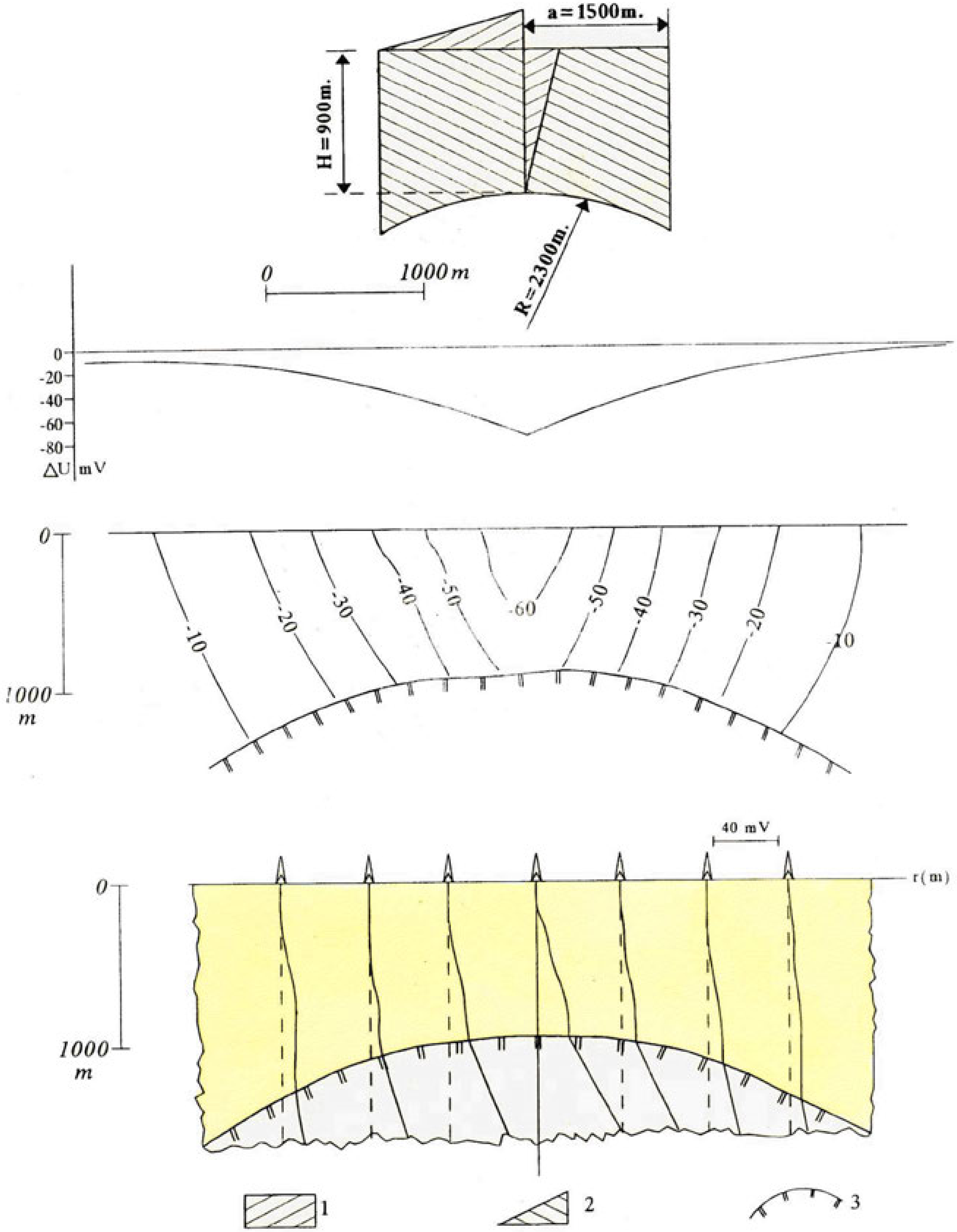


FIG. 7. Theoretical model of the self-potential field distribution in a shallow oil and gas reservoir area. 1- The reduction coefficient plot in the horizontal and vertical directions; 2- The reduced rocks zone over the reservoir; 3 - Top of the oil and gas reservoir.

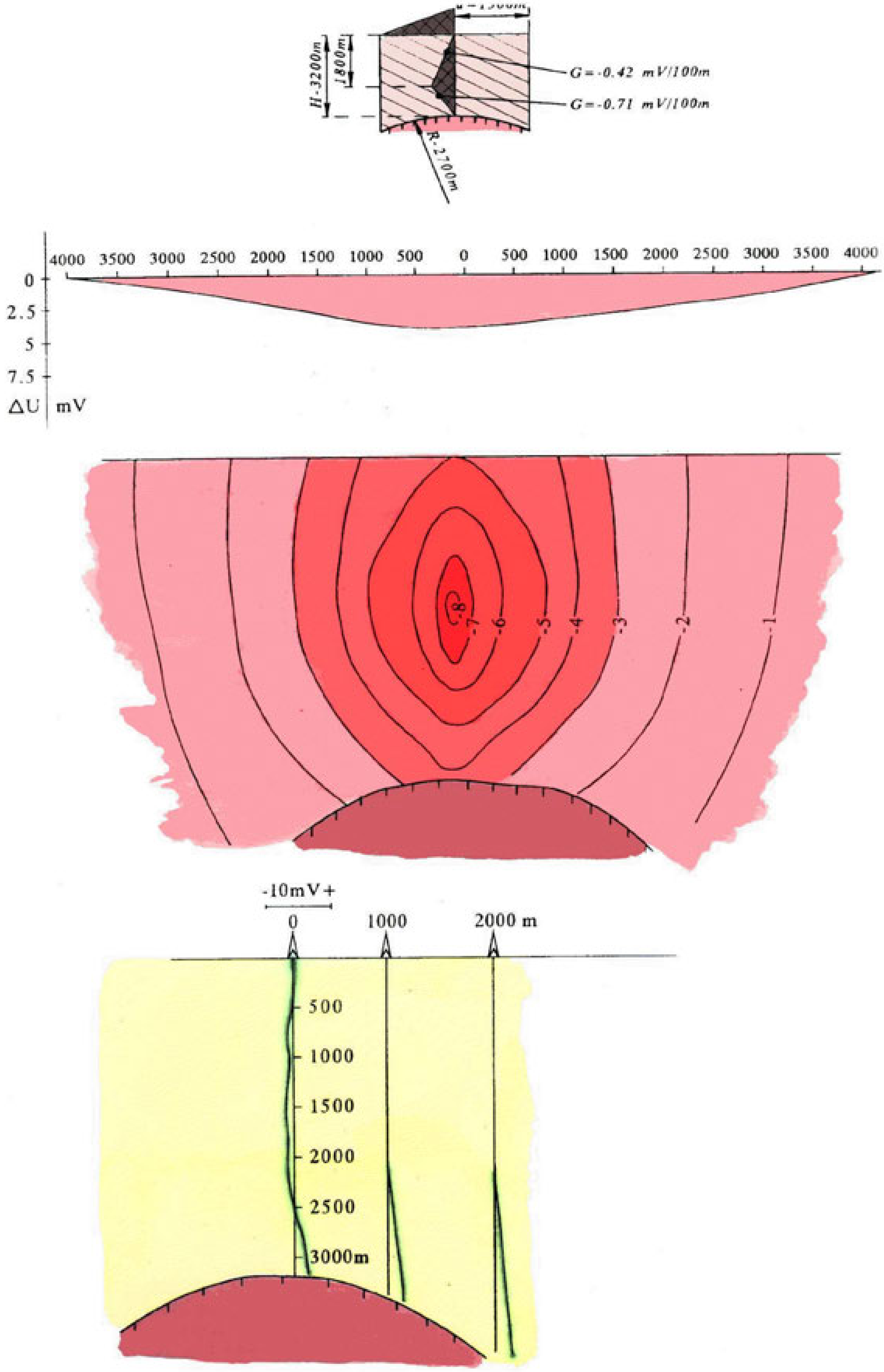


FIG. 8. Theoretical model of the self-potential field distribution in a depth oil and gas reservoir area. The legend as in Fig. 7.

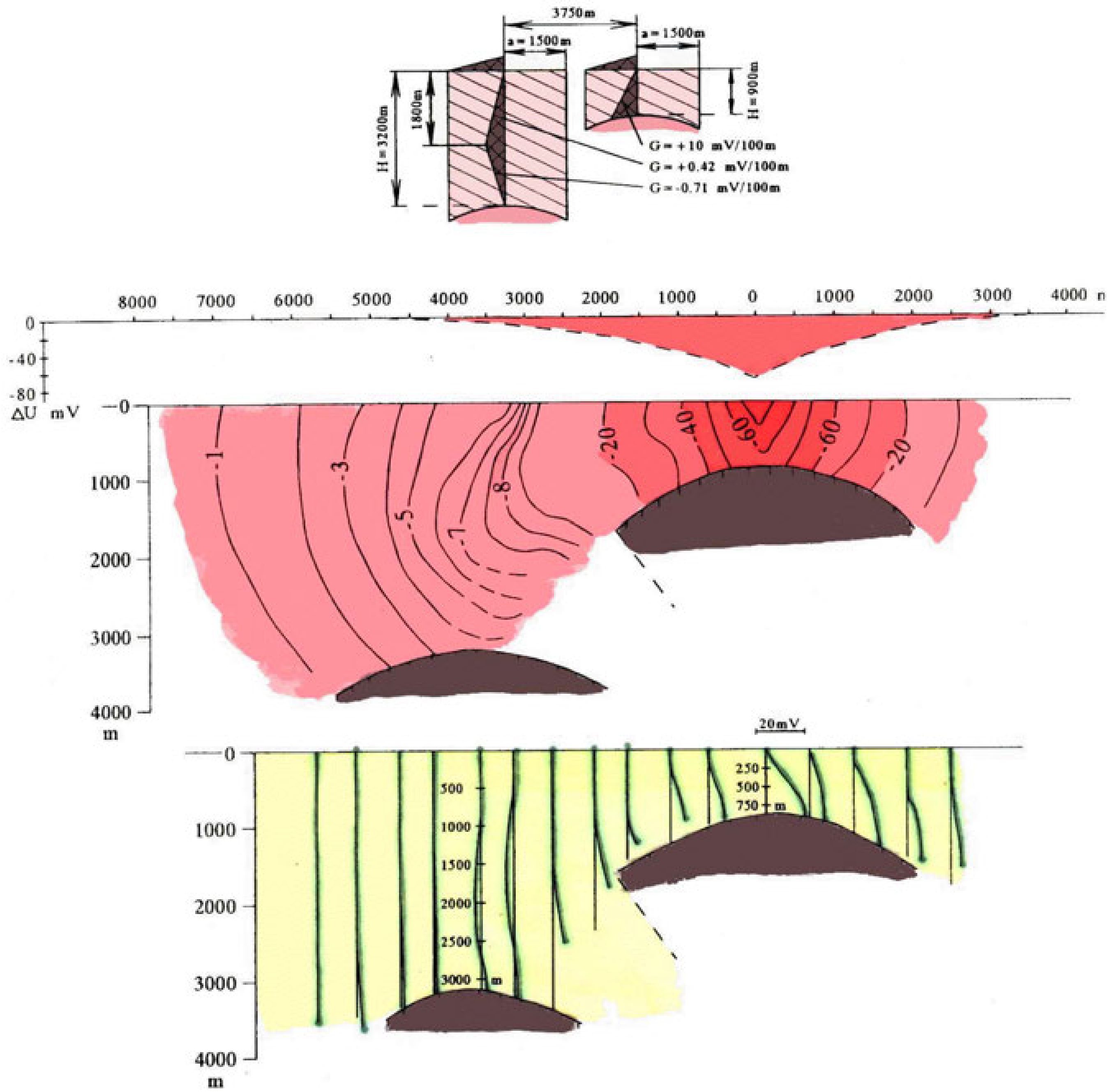


FIG. 9. Theoretical model of the self-potential field distribution in two oil and gas reservoirs, which are located at different depth. The legend as in Fig. 7.

Polarization logs (SP) (Fig. 5) (Frasheri, *et al*., 1981). The vertical gradient of the SP reaches up to 10 mV/100m in the wells inside of the oil deposits area. It becomes zero in wells, which are located outside of the oil-water contour area. Several hearths with higher gradient values were observed in the map of the PS gradient (Fig. 6). This fact demonstrates that the reducing process of the rocks does not occur equally everywhere in the geological section. The same phenomena have been observed in the vertical plane, too. They depend on the geochemical conditions of the rocks in different depth over the oil reservoir. It is necessary to be mentioned that the PS vertical gradient has been observed also in some wells with oil imprint only.

The field survey results have been verified by a mathematical modeling (Fig.7 and Fig. 8). In Figure 7 the reservoir is located at depth of 900 m and the intensively reduced rocks are located near of the Earth surface. In the model of the Figure 8 the reservoir is located at 3500 m depth, and the intensively reduced rocks occur in the middle of the geological section. Complicated anomaly shapes are observed in the case of two reservoirs, located close to each other (Fig. 9).

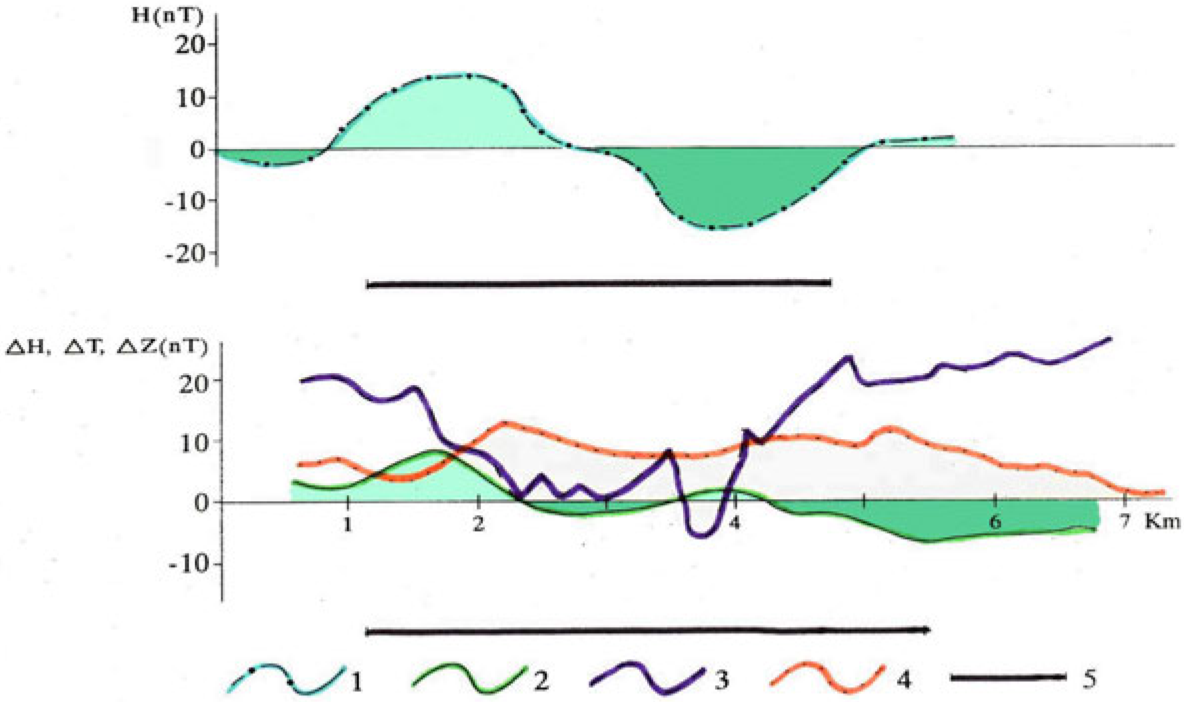


FIG. 10. Synthetic and observed magnetic anomalies in the 1-1 line, Ballshi oil and gas reservoir. 1 - Computed horizontal magnetic component *H*; 2- Observed horizontal magnetic component *H*; 3- Total magnetic anomaly Δ*T*; 4-Computed vertical magnetic component *Z*; 5- Projection of the oil-water contour at survey line.

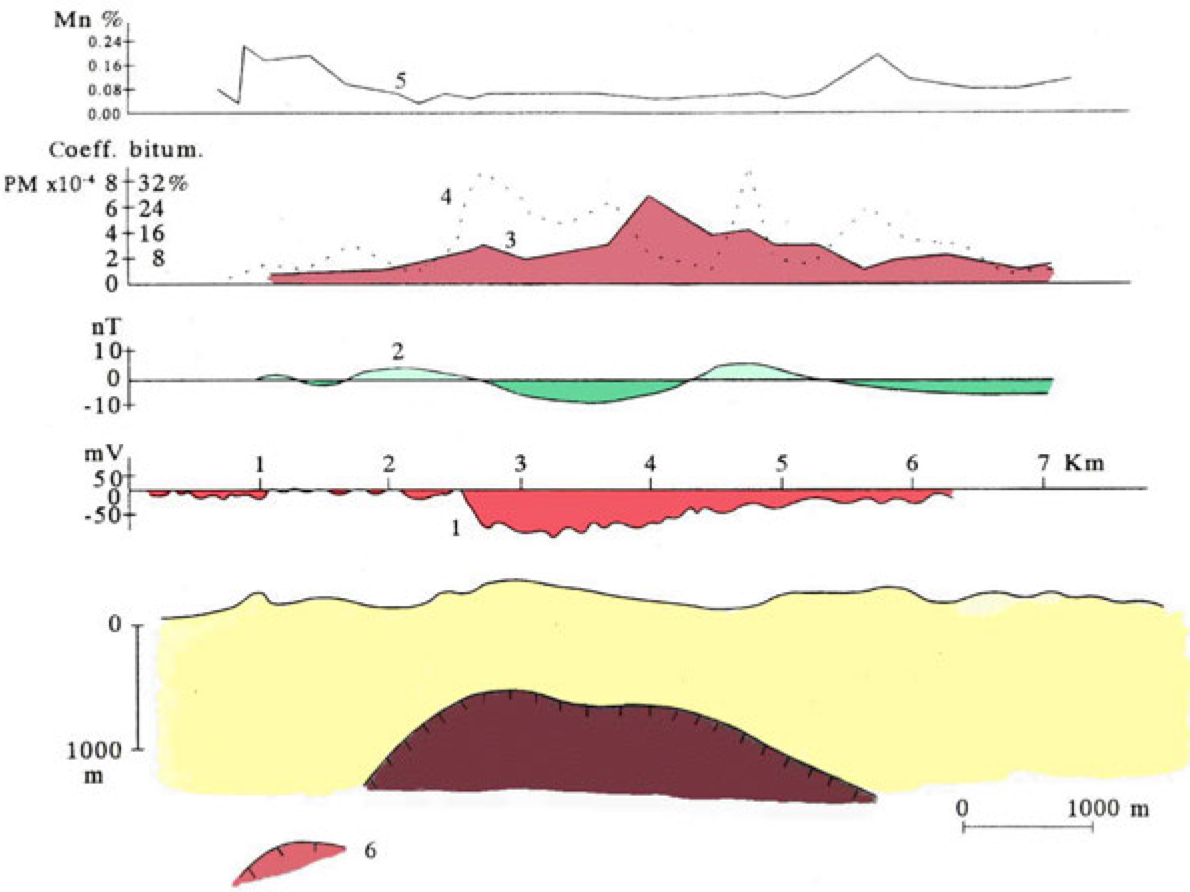


FIG. 11. Integrated geophysical-geochemical anomalies along 1-1 line, Ballshi oil and gas reservoir. 1 - Self-potential anomaly; 2 - Residual total magnetic anomaly of 4th order, recomputing at 250 m depth; 3 - Total gas anomaly; 4- Bituminous anomaly; 5- Manganese content anomaly; 6- Top of the oil and gas reservoir.

The electric field of natural currents is accompanied with magnetic anomaly, which can be observed in the reservoir area (Fig. 10). The total magnetic field anomaly has an amplitude about 5-8 nT (Frasheri, *et al.*, 1982). The magnetic field distribution over the oil reservoir is represented very "noisy". This fact could be explained by the heterogeneous distribution of the secondary magnetite in the subsurface ground, which is an element of the multielementary geochemical anomaly. Over the reservoir a weak pH anomaly is observed (Fig. 4).

SP anomalies on the Earth surface over syngenetic gas reservoirs are not observed, generally. In some anomaly cases, the amplitudes are very small, of the order –20 up to –30 mV, and potential contours represent a mosaic shape.

The studies of SP in various areas of Albania gave evidences for the existence of anomalies connected with the diffusion-adsorption or filtering processes. For the selection of anomalies that are linked with the presence of epigenetic reducing geochemical facies over the oil reservoirs it is necessary geoelectrical and magnetic surveys to be performed in complex with geochemical studies of the redox potential E_h, as well as gas, bitumen and microelements anomalies surveys.

The complex geophysical-geochemical anomalies along line I-I, over the Ballshi oil and gas reservoir are shown in Figure 11 (see also Fig. 2).

CONCLUSIONS

1. SP anomalies of magnitude up to –100 mV are observed on the ground surface over the oil reservoirs in Albania located at depths from 900-4000 meters.
2. SP anomalies are observed also in depth with a positive drift of the SP plot "zero line", which have the vertical gradient up to 10 mV/100 m.
3. SP anomalies are an inherent element of the complex, multi-element geophysical and geochemical anomaly over the oil reservoirs.
4. Complex geophysical-geochemical anomalies represent an indicator for the probability of the presence of commercial oil reservoir in depth.

ACKNOWLEDGMENTS

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IMPACT OF THE CLIMATE CHANGE ON ADRIATIC SEA HYDROLOGY

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Abstract

In the paper there are presented the impact of the climate change on Adriatic Sea hydrology. The study is based on the results of inversion of 6 thermologs data for the ground surface temperature history in Albania, and climate change according to the meteorological data from different regions of Albania. The wells and the meteorological stations are located in Sedimentary Basin of Albania, at the field region in the west of Central Albania and in the ophiolitic belt in the mountainous region of the northeast Albania. Based on inversion data at coastal plane western region of Albania, GST history presents a gradual cooling before a middle of the 19th century, followed by 0.6 K warming. Climate warming of 0.6 K in the 20th century is observed also in mountainous northwestern Albania. This warming mainly after the second half of the 20th century is presented also by meteorological data. The warming has caused its impact on country climate, inland and coastal water systems and ecosystems of the Albania

Keywords: Ground Surface Temperature, Climate Changes, Hydrology, Hydrographic System, Adriatic Sea, Environmental Impact.

1. Introduction

Processes of the forming and circulation of the Adriatic Sea water mass, as is well known, presents a discussible phenomenon of the Mediterranean oceanographic dynamics. One of the main factors, which have determined these processes, is water discharge from the Albanian Hydrographic System into Adriatic Sea (Pano N. 1964, 1965, 1978, 1995 e 1998). Analyze of the factors that conditioned water discharge and their impact on Adriatic Sea Hydrology are presented in the paper.

Climate, geomorphology, lithology and geographical situation of the Albanian Hydrographic Network Catchment, are caused their impact on the water discharge from Albania into Adriatic Sea. Its impact has been observed on some directions:

- Country climate change,
- Water systems and water resources changes. Impact of inland water resources changes on the hydrographic regime of the Adriatic Sea.
- Mechanism of the forming and circulation of the South Adriatic Sea water.

In the first part of the paper is presented detailed analyzes of the climate change in Albania (Frasheri 1995, Frasheri et al. 1999, 2002. Albania lies in a subtropical zone. It is a Mediterranean country. Winter is relatively short and mild, humid near the seaside areas. Summer lasts very long and it is hot and dry. To the east, in the mountain areas, the climate is Mediterranean mountainous. There, the temperature is lower than in seaside zones and the

raining decrease. Sunshine varies from 2560 hours per year in Tirana, down to 2046 hours in Kukesi City. Average yearly temperature varies from 16.5^{o}C in Vlora City, 11.8^{o}C in Kukes and 7.0^{o}C in the northern area of the Albanian Alps. In Albania the rainfall is in average about 1430 mm/year. Albanian Alps is one of the most humid territories in Europe, up to 4444 mm/year rainfalls (Albanian Climate, 1978, Boriçi, M. and Demiraj, E. 1990, Mici, A. et al 1975). The climate in Albania varies from a region to the other, according to the location compared with the seaside, to the seasons, years, and centuries. The ground temperatures are conditioned by geographical position of the area, area's geology, and ground lithology, dynamics of the underground waters, meteorological conditions, and season. The climate change studies, are based on geothermal inversion results and meteorological observation data. (Frasheri A. 1995, Frasheri A. et al. 1999, 2002). There is analyzed the ground surface history (GSH) and paleoclimate change according to the temperature measurements in the different wells in Albania. Climate changes during the last half of the XX century has been analyzed also based on the meteorological data.

There are estimated continental water flow, created by atmospheric rainfalls and its impact on processes of the forming and circulation of the Adriatic Sea water mass has been analyzed.

According to the complicated nature of the Albanian Hydrographic System, in the second part of the paper, is presented the analytical methodic for estimation of the total continental water flow in this system. From multi annual analysis of the water flow, in the paper are selected and analyzed characteristics of two characteristic years, with great (p=1%) and small (p=99%) water flow.

In the last part of the paper the processes of the forming and circulation of the Adriatic Sea water mass impact for wet and dry years are analyzed. Results of the Albanian Expeditions “Saranda-1963” and “Patosi 1964”, have used for the analysis of year with great water flow. For the dry year have analyzed Italian-Albanian Expedition “Italia 2001-2002” data.

2. Material and methods

Cilimate change are analyzed in two directions: firstly by temperature record in the deep wells and shallow boreholes, and secondly by the meteorological observations data. The ground surface temperature reconstruction for long period, about 5 centuries, has been performed by estimation of the ground surface temperature changes at the past, according to the present-day distribution of the temperature at the depth, recorded in the borehole. The study of geothermal field of Albania has been carried out based on the temperature logging in the wells and boreholes (Çermak, V. et al 1996, Frasheri, A. and Çermak, V. et al. 1995, 2004). Six thermoplots were used for inversion of the ground surface temperature history. Well Ko-10, Arza-31, are located at the plane region in the west of Central Albania (Fig. 1). Boreholes Vl-1127, Gurth-595, Krasta-1 and Ragam-168 are located in the mountainous region of the northeast of the Albania (Fig. 1).

Air and ground temperatures, total annual rainfall quantity, wind speed and wetness, which are analyzed by records in Meteorological Stations (Fig. 1). These stations are located in different plane regions (Shkodra, Tirana, Kuçova and Fier) and in mountainous region of Albania (Kukes), where the investigated wells are situated (Albanian Climate, 1978, Boriçi, M. and Demiraj E. 1990, Gjoka, L. 1990, Mici, A. et al 1975, the data for 1985-2000 after Mustaqi V.).

Water potential of the Albanian Rivers System have been evaluated by a specific way, because this System is very complicated (Pano N. 1964, 1965, 1978, 1995 e 1998). This network has a surface of 43 305 km^2, where 28 500 km^2 is inside the Albanian state territory, and water of the Albanian river system discharge into Adriatic and Ionian Sea. Albanian River System

represents in general a mountainous hydrographic network, with an average altitude 785 m above the sea level. Part of Albanian Hydrographic Network are lake system, Prespa-Ohri, and Scutary with a surface from 270-365 km^2. A karstic phenomenon is very intensive in the limestone formation, which is extended in great surface of the country.

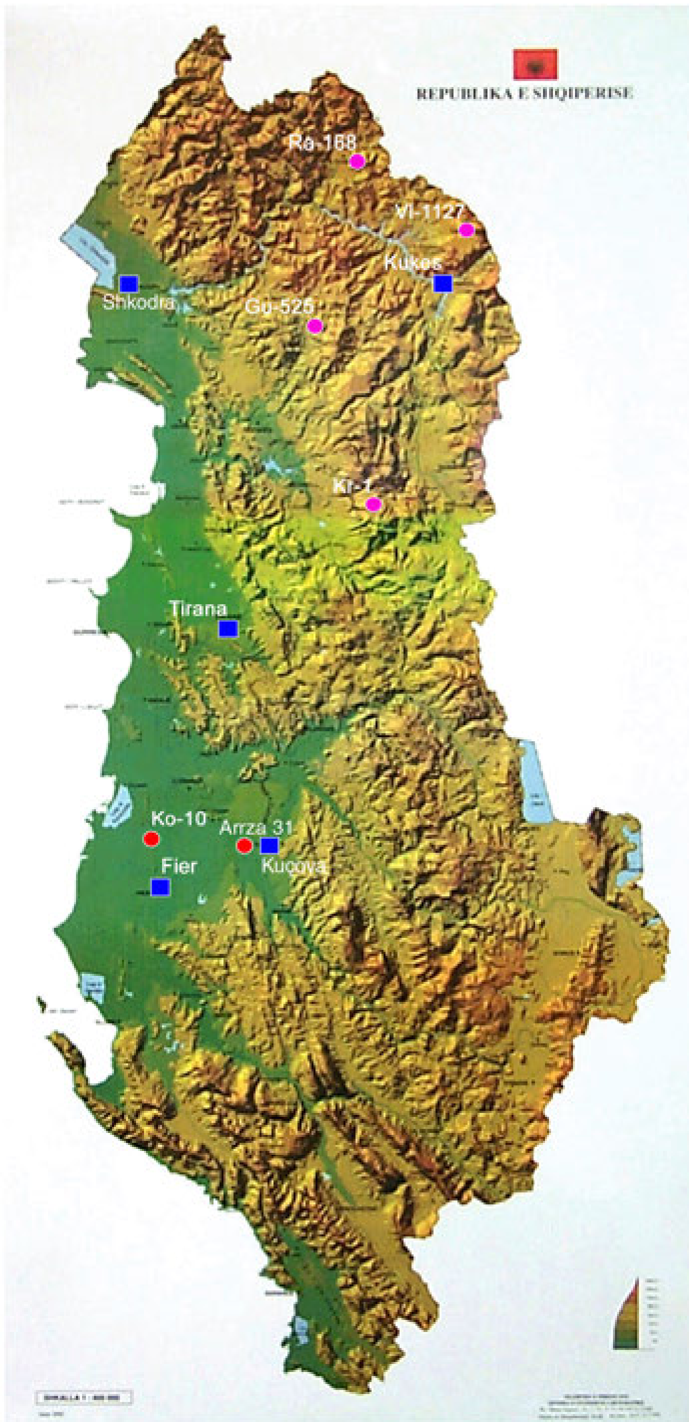

Fig. 1. Map of Albania and location of the Kol-10, Arza-31, Vl-1127, Gurth-595, Krasta-1 and Ragam-168 wells and Meteorological Stations.

Water potential evaluation of the Albanian River Basin based on the multi annual archival data of the Albanian Hydrometeorological Institute of the Academy of Sciences. The monitoring network has more than 22 meteorological and hydrometric stations, during the observed period 20-100 years.

The methodology of the estimation of the water potential, have calculated the annual run-off discharge of the Albanian River System according to the corresponded types of the water supply, structure of the annual discharge distribution, and hydrogeographical types of the river catchment. Estimation of run-off discharge (Qi) are performed for two categories of river basins, with different hydrographical and hydraulical natural conditions:

1) Water system: Scutary Lake-Drini River-Buna River), where the run-off discharge Q_i is computed by $Q_i = F(H_i, Q_l)$, where Q_l represent the discharge of the lateral source..
2) Drini, Mati, Ishmi, Semani , Vjosa River systems, etc), where the run-off discharge Q_i is computed by Q_i-$f(H_i)$, where H_i- level in the river $Q_i=f(H_i)$, where H_i is altitude of the water level river (i) section.

The hydrographical complex Scutary Lake-Drini River-Buna River, with a great catchment surface of about 20 000 km^2, as well is known, is very complicated and unique for its hydraulic regime, in the Mediterranean hydrography. This particularity has made necessary the particular modeling for estimation of the water flow of Buna River.

This particularity has made it difficult to valuate the water flow of Buna through the well known classic methods of the engineering hydrology. A particular way to calculate the water flow of the Buna River is found. This way consist the particular hydraulic conditions:

The discharge of the Buna River, when it flows away from the Scutary Lake Q_2 depends not only from the level of the water H_2, but also on the level H_2 and the Drini River discharge in to the Buna River Q_4. So, the only possibility to calculate the discharge of the Buna River Q_2 is to find the connection $Q_2=f(H_2, Q_4)$. This connection is deducted by the following equations:

$$Q_2 = A_1 \times H_2^B \times \sqrt{\Delta H_{2-3}} \qquad (1)$$

$$Q_3 = (Q_2 + Q_4) = A_1 \times H_3^{B_1} \qquad (2)$$

The dislevel ΔH_{2-3} can be determined through:

$$\Delta H_{2-3} = (H_2 - H_3 \qquad (3)$$

if we put the equation (3) to the putting equation (1) , we will have:

$$Q_2 = A \times H_2^B \times \sqrt{H_2 - H_3} \qquad (4)$$

we find H_2 from equation (4):

$$\frac{Q_2 + Q_4}{A_1} = \left[H_2 - \frac{Q_2^2}{\left(A \times H_2^B\right)^2} \right]^{B_1} \qquad (10)$$

From equation (10) it results:

$$Q_2 = \left\{ A_1 \times \left[H_2 - \frac{Q_2^2}{\left(A \times H_2^B\right)^2} \right]^2 - Q_4 \right\} \qquad (11)$$

Where: A, A_1, and B, B_1 = parameters (A=0.073; A_1=0.025; B=1.61413; B_1=1.85

ΔH_{2-3} - dislevel (H_2-H_3)

Putting the above parameter, equation (11) has the final form:

$$Q_2 = \left\{ 0.025 \times \left[H_2 - \frac{Q_2^2}{(0.0073 \times H_2^{1.61413})^2} \right]^{1.85} - Q_4 \right\} \qquad (12)$$

The Q_2=f(H_2, Q_4) correspond to the results obtained through the hydraulic calculations the dependence Q_3=f(H_3), topomorphometric data, and the hydraulic parameters of the rivers discharge are the basic dependence of this calculation. The methods of Pavllovskiy and Van Te Chen-1963 were used in this calculation. The differences of the discharge Q_2 for all the game of the discharge between both methods are small, about $\delta Q = \pm 3\%$.

Giving standard values to the discharge Q_4 equal to 50, 100, 300 1 500 m^3/s and salving the dependence of Q_2 as an explicit function from the Scutary Lake level H_2 and the Drini discharge Q_4, it was made possible to from a single family of the countable curves of the Buna discharge in the Scutary Lake.

The phenomenon of dry and wet years has always had a significant role and great interest. In this paper, the importance of preliminary hydrologic analyses of the raw data, which, aparat from an estimation of the basic statistic parameters, verification of consistence, representatively, homogeneity an independence, includes an investigation of the periodicity of time series, is discussed.

After evaluation of the water flow Q_i, have been calculated multi annual average discharge $\bar{Q} = \frac{\sum Q_i}{r}$, standard deviation $S = \frac{1}{n-1}\left(Q_i - \bar{Q}\right)^2$, variation coefficient $C_v = \frac{S}{\bar{Q}}$, and asymmetry coefficient $C_s = \frac{n}{(n-1)\times(n-2)} \times \frac{1}{S^3} \times \sum_1^n \left(Q_i - \bar{Q}\right)^3$.

All modeling and calculations have been performed for the model of dry and wet characteristic years, to analyze the climate impact on Albanian Hydrographic System.

Processes of the forming and circulation of the Adriatic Sea water mass have analyzed based on hydrographic data and Results of Albanian Marine Expeditions “Saranda 1963”, “Patosi 1964” for the wet years (Pano N. 1974), and Italian-Albanian Expeditions “Italica I and II, 2000 and 2001” for dry years.

3. Results and discussion

The ground surface temperature reconstruction of the thermoplots of Kolonja-10 and Arza-31 deep wells, which are located at coastal plane region of western Albania, are shown in fig. 2. As it is seen in this figure, the GST history yielded by tighter inversion of Ko-10, presents a gradual cooling of 0.6 K, before a middle of the 19th century. Later followed by 0.6 K warming, with a gradient 5.4 mK/years, that seems quite reasonable and is consistent with generally accepted ideas about the climate of the last 2-3 centuries. On the contrary, the paleothermal history, obtained from Arza-31 well, presents a monotone warming of 1,7 K, by a gradient 5.7 mK/year, during the 17th and 19th centuries. This trend of the warming has only explanation caused by a deforestation of the area and presence of the paleo-swamp.

Fig. 3 shows a GST history of Vl-1127, Gurth-595, Krasta-1 and Ragam-168 boreholes, which are located in the mountainous regions of Northeast Albania. Some changes are observed in these regions as to the cooling of 0.2 K during the 19th century. Later, the warming trend of 0.6 K during the 20th century, by a gradient 6.7 mK/year. Warming gradient increasing at mountainous regions, in comparison with coastal areas, is caused by intensive deforestation during the last half of 20th century.

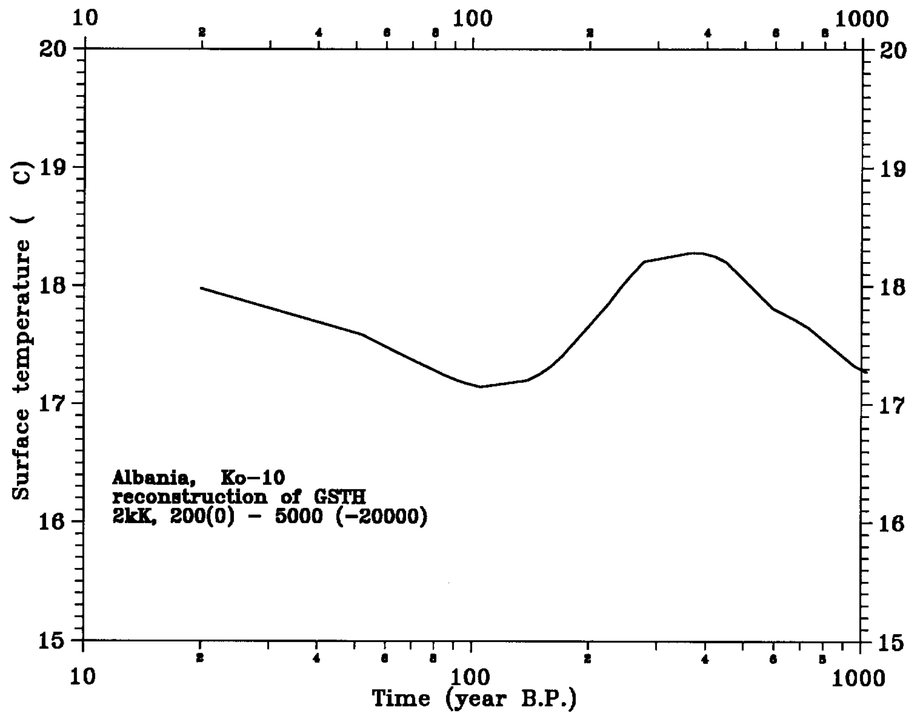

Fig. 2. Ground surface temperature history according to thermoplot of Ko-10 and Arza-31 wells (According to the Šafanda, J. calculations).

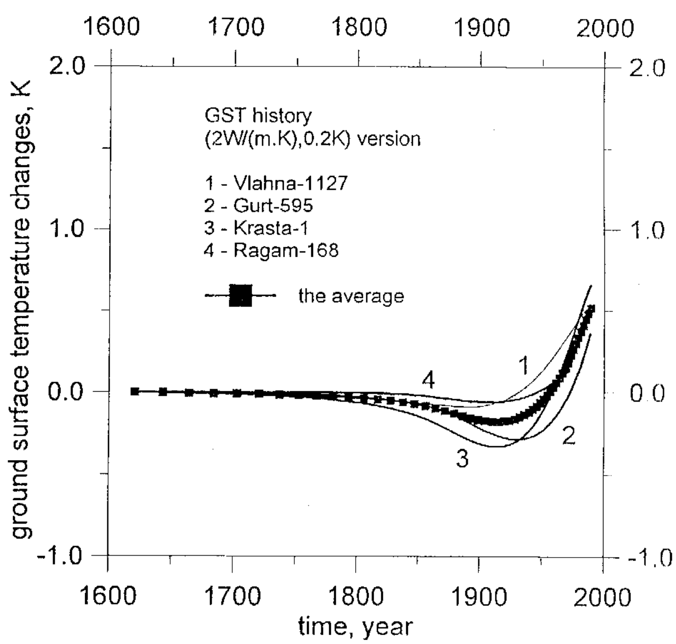

Fig. 3. Ground surface temperature history according to thermoplot of Vl.-1127, Gurth-595, Krasta-1 and Ragam-168 boreholes (According to the Čermak, V. and Safanda, J. calculations).

Climate changes in Albania are observed also by the hydrometeorological studies. Fig. 4 presents graphics of yearly average temperature of the air in Tirana and Shkodra Meteorological Stations, for the period from 1931 to 2000. As well known, Tirana is located in Central Albania. In general, the end of first observes half 20th century, a warming of climate, about 1^{o}C. Thirty quarter of 20th century is characterized by a cooling of 0.6^{o}C, and later, up to present a warming of 1.2^{o}C. The same climate changes are observed also at Shkodra City, in northwestern plane area of Albania. The cross correlation coefficient is C_c = 0.78 between variation curves of the average annual temperatures of both of these stations. Warming trend of maximum 1.2^{o}C, in particular after seventy years, is observed in all Albanian territory (Fig. 5). There are good cross correlation between variation curves of the average annual temperatures of Shkodra, Tirana and Kukesi, respectively C_c = 0.78 and 0.79. Weak cross correlation C_c = 0.58-0.68 is observed between temperature variation of the Kuçova area and other northern regions. This phenomenon presents the influence of the local character of the climate changes of Kuçova area. Warming of the soil is more intensive than air warming (Fig. 6).

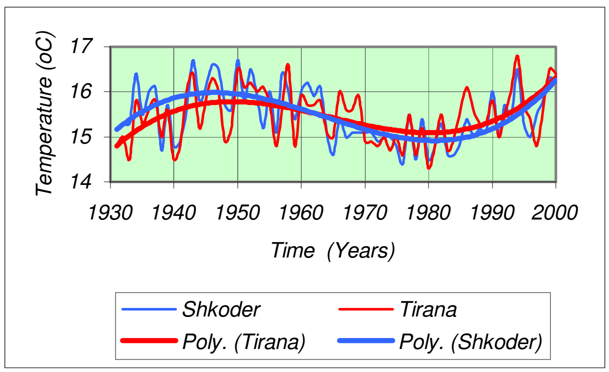

Fig. 4. Air Average Annual Temperature Variation at Tirana and Shkodra Meteorological Stations (Period 1931-2000).

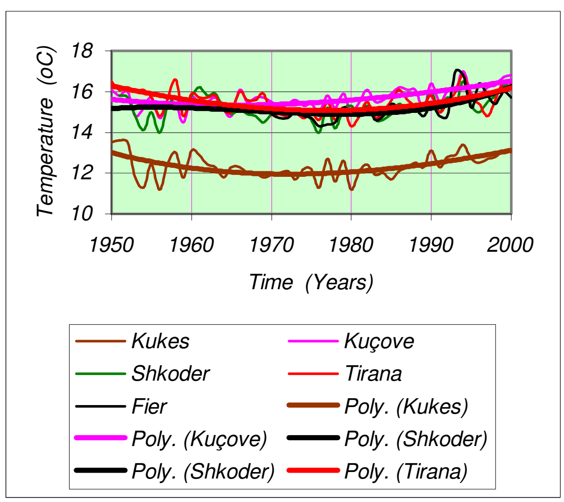

Fig. 5. Cross-correlation of the Air Average Annual Temperature variations at Shkodra, Kukes, Tirana, Kuçova and Fier Meteorological Stations (Period 1950-2000).

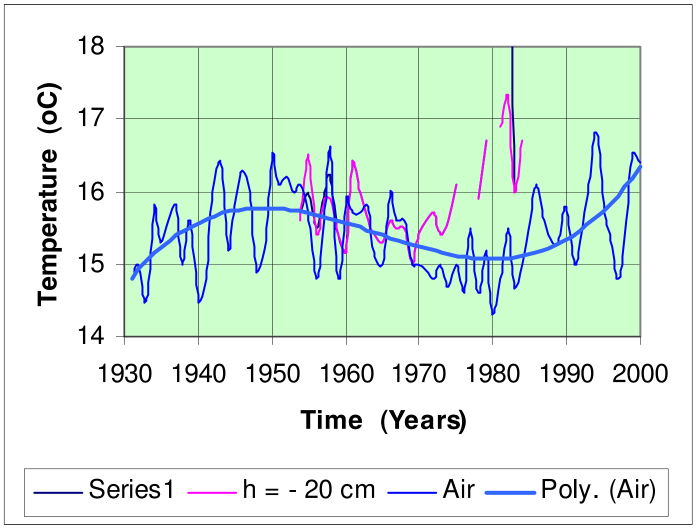

Fig. 6. Air and Ground Average Annual Temperature Variation at Tirana Meteorological Station Station.

The meteorological data shows that the warming trend is not a monotone one. In short intervals are observed cooling and warming (Fig. 4, 5, 6). The meteorological studies have verified warming of the climate during the last quarter of the XXth century, too. It has been consisted that: "Around the 1980's a warming trend is observed" (Boriçi M., Demiraj E. 1990, Demiraj E. et al 1996).

The warming period in Albania is accompanied with changes of the rainfall regime., wind speed and wetness. There are observed a decreasing of the total year rainfall quantity, for about 200-400 mm. (Fig. 7,8,9).

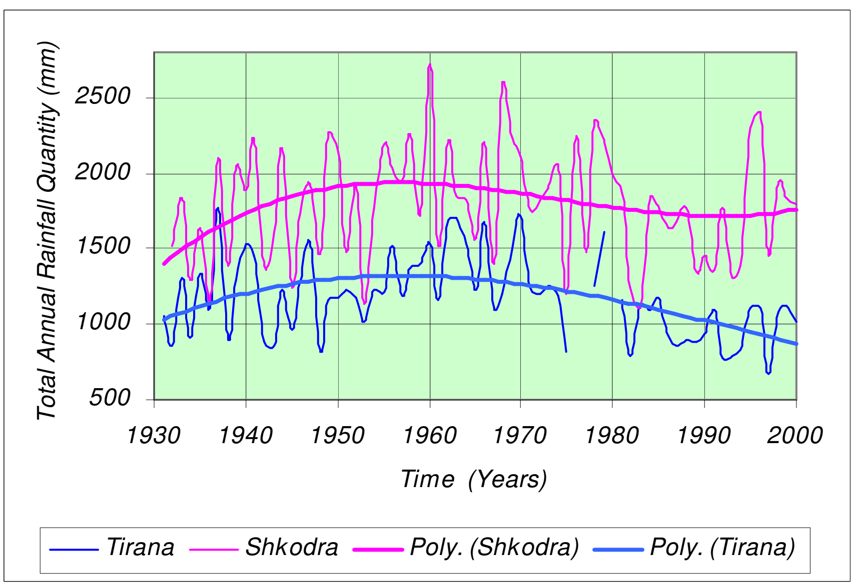

Fig. 7. Total year rainfall quantity of the Tirana and Shkodra Meteorological Station (Period 1930-2000).

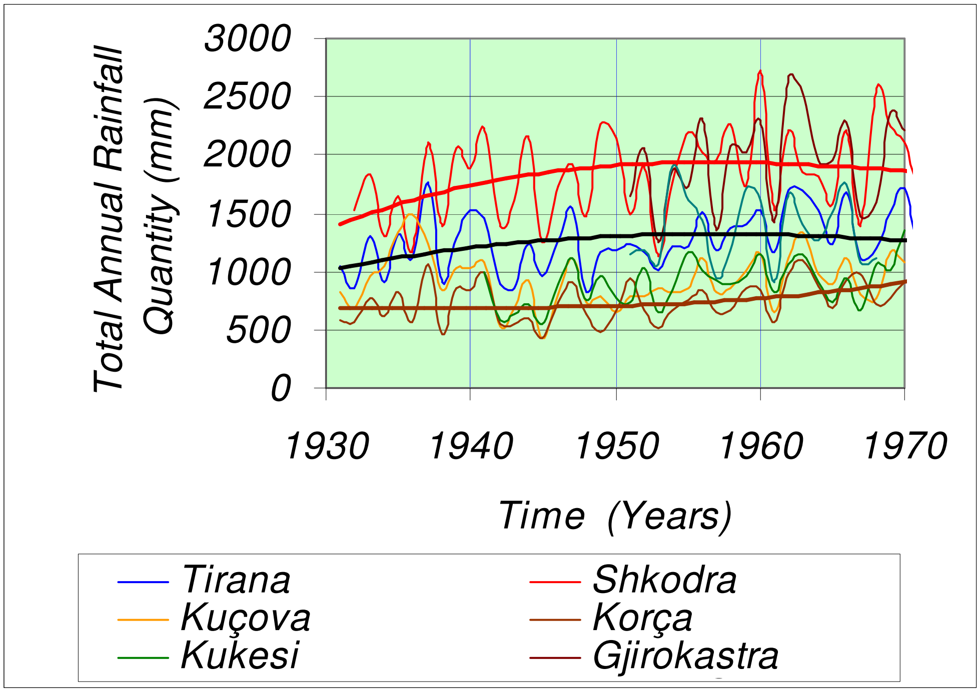

Fig. 8. Cross correlation of the Total Year Rainfall Quantity of the Tirana, Shkodra, Kuçova, Korça, Kukesi, Gjirokaster, Vlora Meteorological Station (Period 1930-1970).

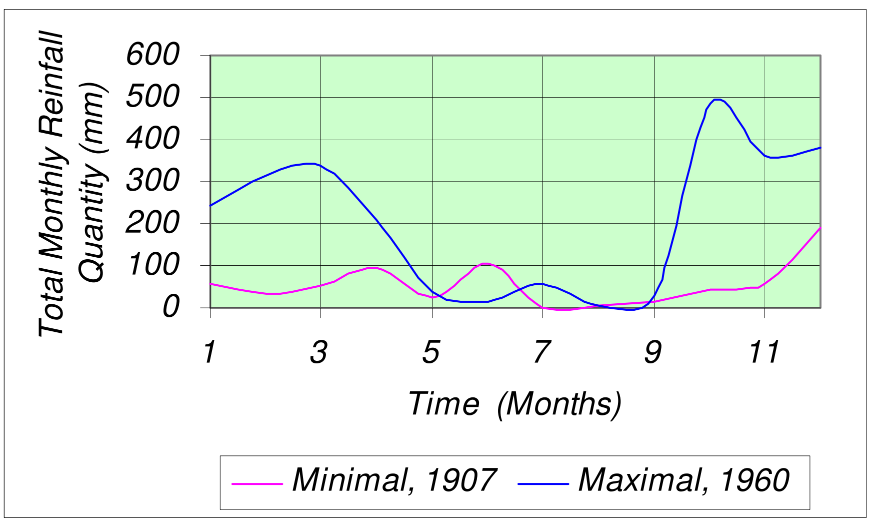

Fig. 9. Total Year Rainfall Quantity in the most dry and wet year, respectively, of the Shkodra Meteorological Station (respectively 1907 and 1960 years).

In the dependence of the geographical location of the areas changes the cross correlation of the rainfall quantity: Tirana area with Shkodra area C_c=0.62, with Korça C_c=0.81, Kuçova C_c=0.66, Kukesi C_c=0.88, Gjirokaster C_c=0.88, Vlora C_c=0.53, during the period of 1930-1970. Fig. 8 is presented the difference of the total year rainfall quantity in the most dry and wet years,

respectively 1907 and 1960. The warming have accompanied with decreasing of the wind speed about 1.5 m/sec and 5% increasing of the wetness, during the period of 1950-1994 (Fig. 10).

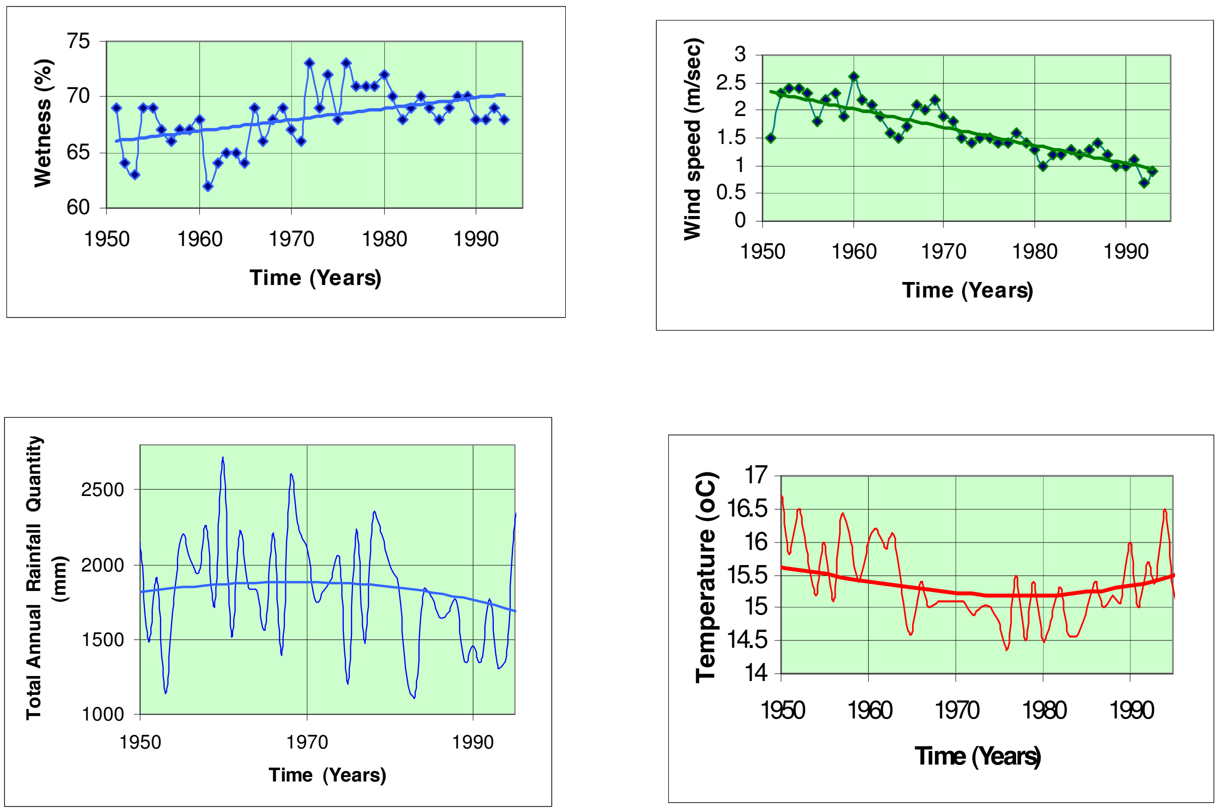

Fig. 10. Air Average Annual Temperature, Total Year Rainfall Quantity, Wind Speed and Wetnees Variations, at Shkodra Meteorological Stations (Period 1950-1994).

This warming is part of the global Earth warming during the second half of XX century.

Its impact has been observed also on water systems and water resources. Inland water resources change has its impact on the hydrographic regime of the Adriatic Sea. Processes of the forming and circulation of the Adriatic Sea water mass, as is well known, presents a discussible phenomenon of the oceanographic dynamics. These processes, in the particularly intensity of the penetration of the Levantine hot and saline waters in the Adriatic Sea through Otranto Strait, for long time period have been explained by the external phenomena from this sea (Buljan M, 1948, 1955, Armanda Zore 1960). Has been supposed that Adriatic Sea doesn't participate in this penetration.

Based on two Albanian Oceanographic Expedition "Saranda-1963" and "Patosi-1964" collected data has been proposed other mechanism of the forming and circulation of the Adriatic Sea water (Pano 1974, 1984, 1994, Pano et al. 1997). There are great impact of the specific natural conditions of the Albanian Hydrographic System catchment, with a surface of 43 304 km^2, in the particularly extraordinary atmospheric winters, in these processes.

The water potentials of Albanian rivers system is Wo = $41{,}249.10^9$ m^3 that correspond to a mean annual discharge of Qo = 1306 m^3/s. So, Albania is one of high specific water potential

in Mediterranean. The multi annual data have arguments that the total discharge of the Albanian rivers system in the Adriatic and Ionian Seas varies in very wide limits. Minimal discharge is 700-800 m^3/s for the hydrological dry years of low precipitation, up to maximal values 1900-2200 m^3/s for the hydrological wet years of high precipitation. Buna River is one of the most important rivers of the Mediterranean Basin. This river, together with Po River in Italy, are determinant in the water balance of the Adriatic Sea.

View of Mati River discharge in Adriatic Sea.

The oceanographically situation of the wet years 1963-1964 has been characterized by formation of "The Bridge" with continental water in the Adriatic sea (Fig. 11). "The Bridge" is closely linked with the intensity of the river flow (Pano N. 1974). The eastern water mass are formed in SE Adriatic Sea area by the discharge of the Albanian rivers, and the Adriatic North water masses are formed by the discharge of Po River, Italy. This "Bridge", includes not only the surface layer, but also the Levant Intermediate Water (LIW) up to 600 m. depth. Low salt content and density of the seawaters are observed over "the bridge" (Fig. 12, 13. 14). This phenomenon has a complex and an important influence on many dynamics aspects of the formation Adriatic Deep Water (ADW), the deportation Levant Intermediate Water (LIW), and the monitoring mechanism of water into Otranto Street. All these peculiarities have impact also on the seawater temperature distribution in this area (Fig. 15). Consequently, "The Bridge" with the continental water in South Adriatic is an important component of the hydrological regime of the Sea. It is important to observed that under "the bridge" is located also an heat flow density at the sea bottom (Geothermal Atlas of Europe, 1992) (Fig. 16). This figure shows that "the Bridge" direction is corresponds with the prolongation of well-known Scutary-Pec regional tectonic transversal over the Albanides onshore.

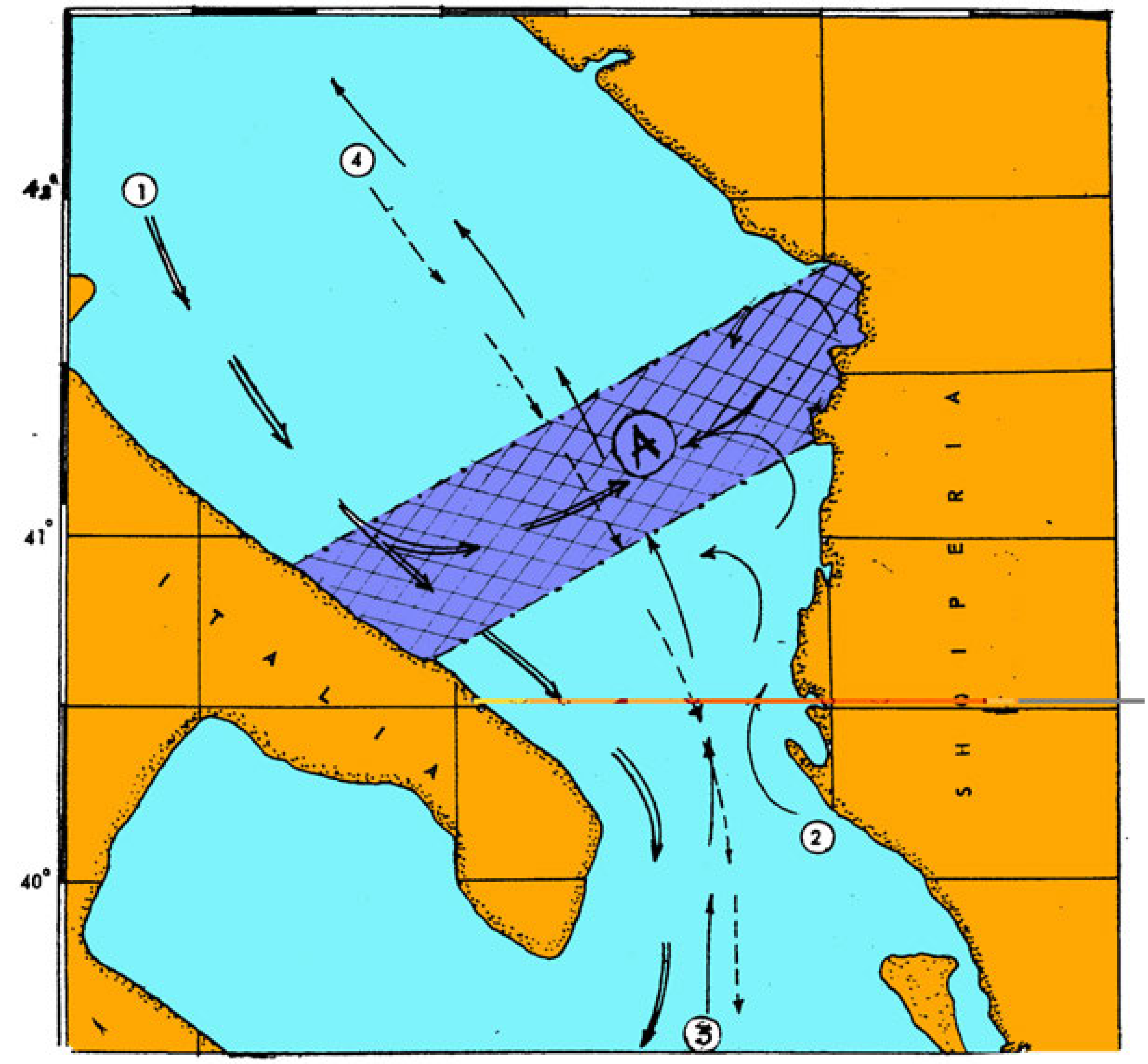

Fig. 11. “The Bridge” of continental water in the Adriatic Sea.

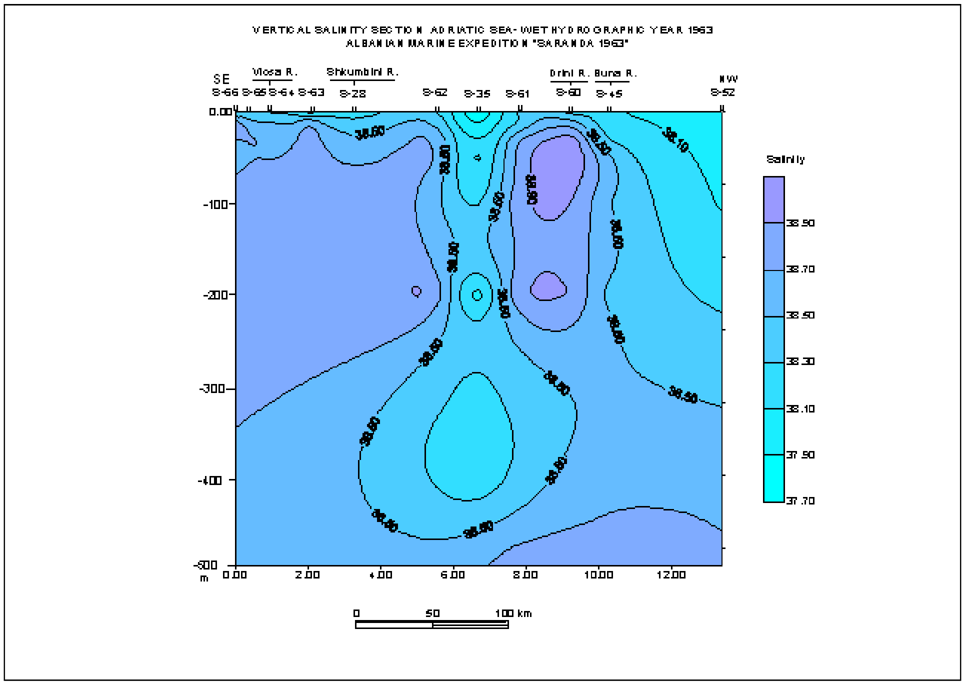

Fig. 12. Vertical salinity section 1-1, Adriatic Sea, wet hydrographical year 1963.

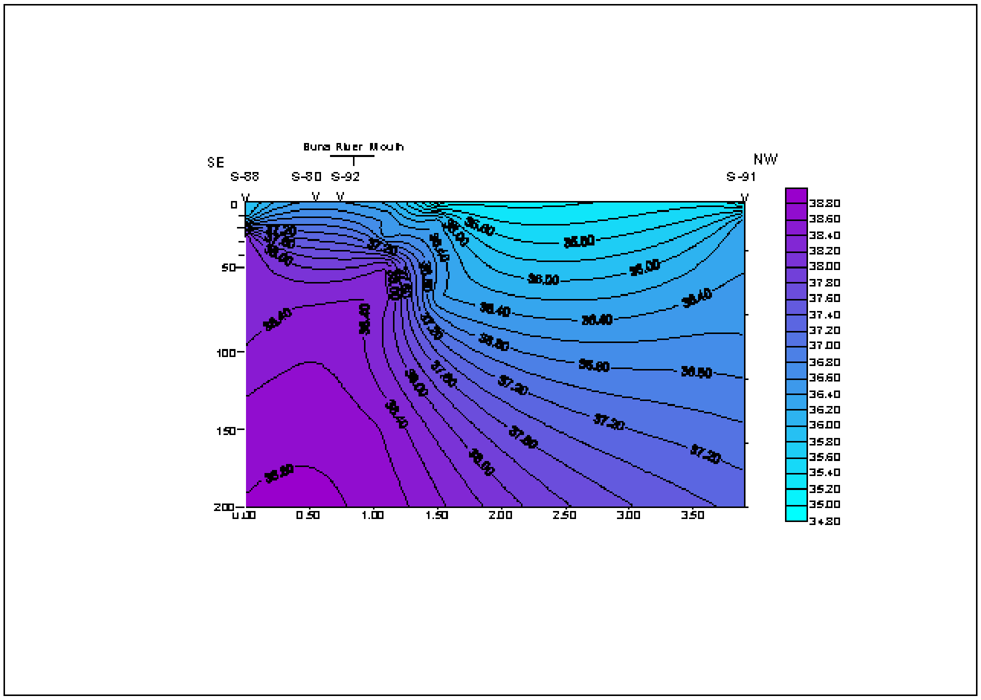

Fig. 13. Vertical salinity section 2-2, Adriatic Sea, wet hydrographical year 1963.

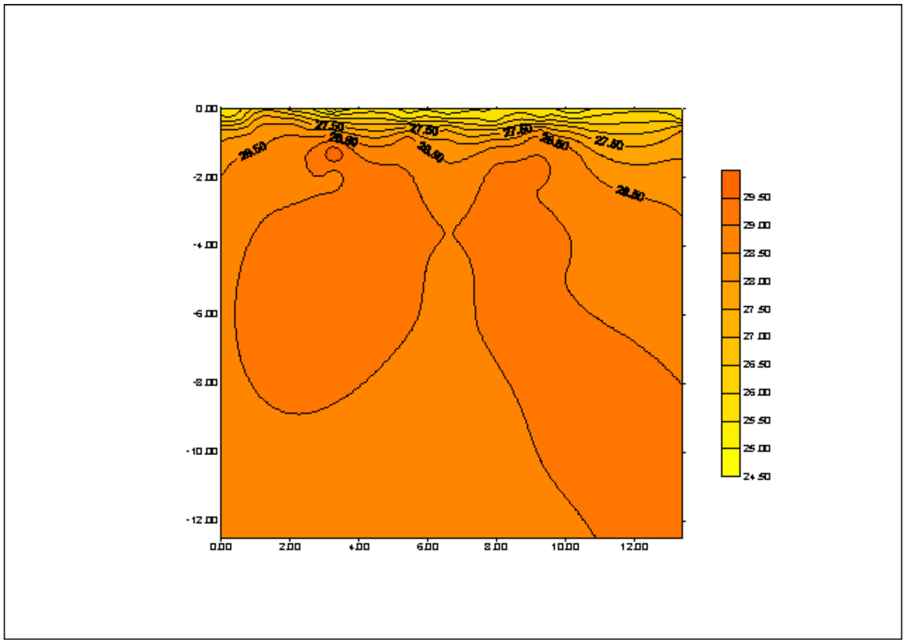

Fig. 14. Vertical density section 1-1, Adriatic Sea, wet hydrographical year 1963.

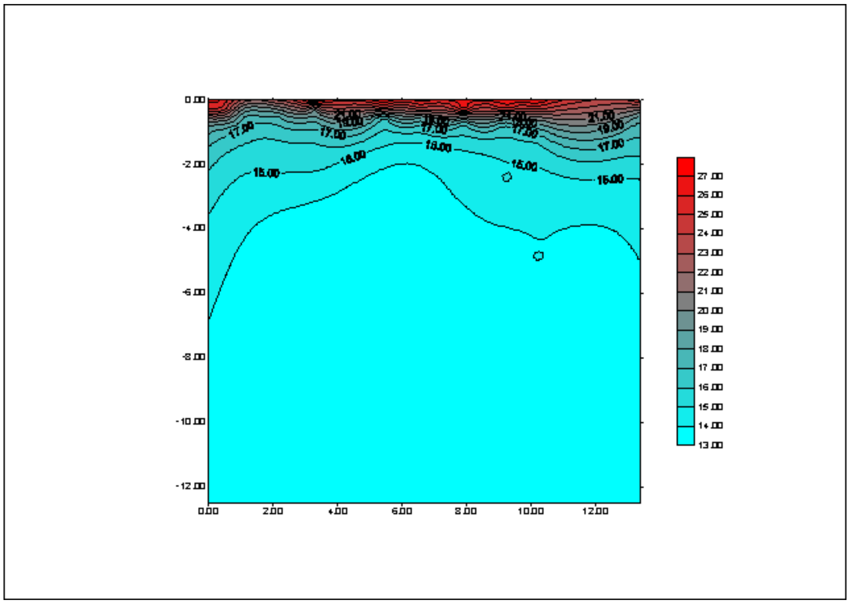

Fig. 15. Vertical temperature section 1-1, Adriatic Sea, wet hydrographical year 1963.

Consequently, climate change in Albania, in the complex, has impact on some directions:

- Country climate,
- Water systems and water resources. The rainfall regime changes have their consequences in the fresh water resources of the country, of surface's and underground waters.
- Inland water resources changes have their impact on the hydrographic regime of the Adriatic Sea.

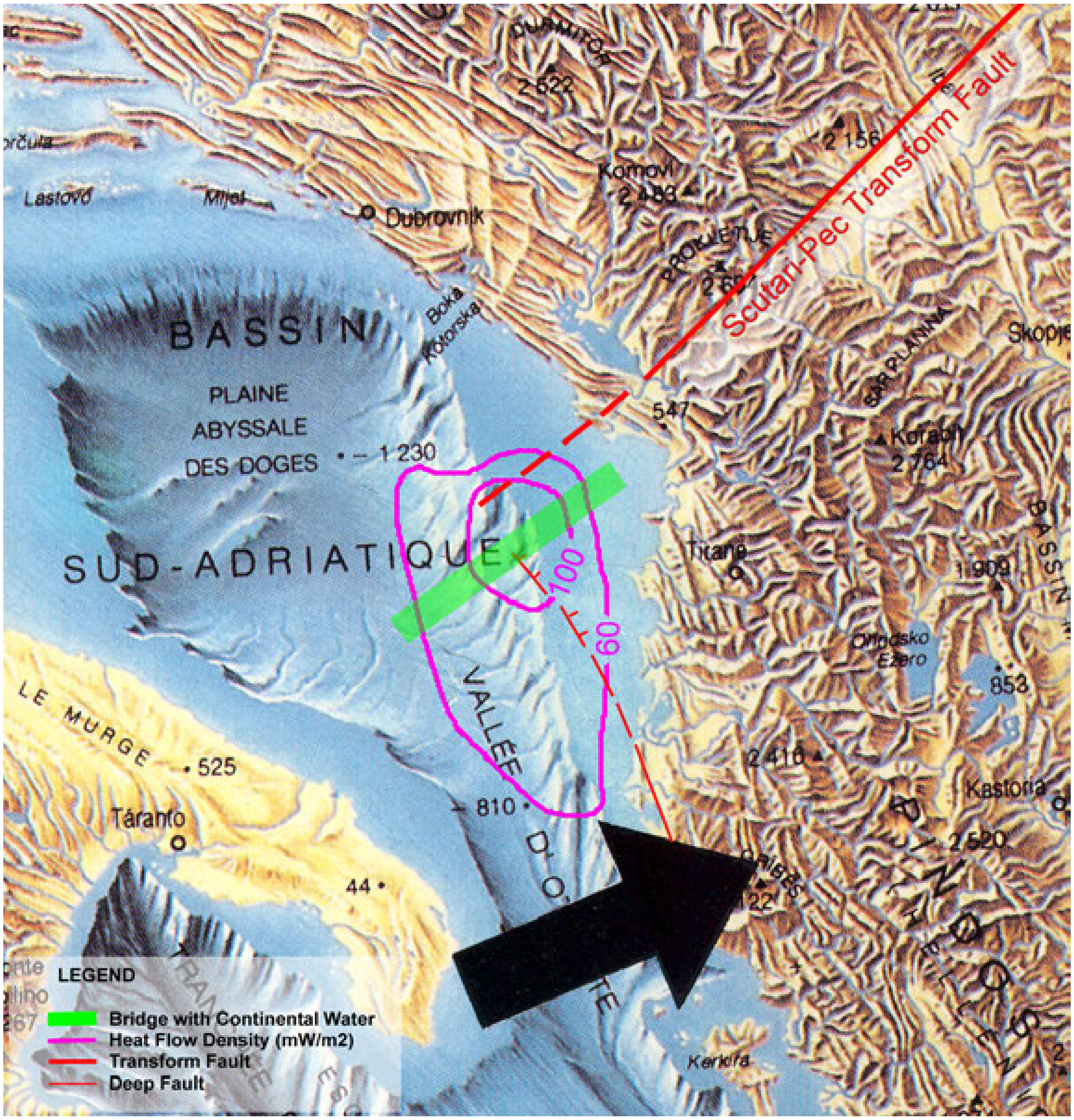

Fig. 16. Adriatic Heat Flow Density anomaly.

- Ecosystems, and biodiversity, in the particularly in the water's flora and fauna. Temperature augmenting has caused increasing of the evaporation in the water systems. Consequently in the river system, reservoirs, wetlands, lakes and lagoon system has been observed thermal stress. In very beautiful ecosystems of Albanian lagoon as Narta, Karavasta, Kune-Vaini and Micro Prespa Lake etc. thermal stress has its impact, first of all on the biodiversity. This stress is extended also in the shallow coastal waters; consequently there are observed diminution of the fish quantity.
- Adriaric Sea hydrology.

4. Conclusions

Based on the results of inversion of the thermologs data, recorded in deep wells and boreholes, for the evaluation of the ground surface temperature GST history and hydrometeorological data, we have arrived in following conclusions:

1. The climate at coastal plane region of Western of Albania was cooled of .6 K before of middle of 19th century. Later a warming of 0.6 K occurred, from last quarter of 19th until present-day.
2. Temperature records in northwestern mountainous region of Albania confirmed also a climate warming of 0.6 K during 20th century. At mountains regions, the warming has started about quarter of century later than at coastal plane area of western Albania.
3. Warming, mainly during the last quarter of the 20th century, is demonstrated also by meteorological data.
4. The rainfall regime changes have their consequences in the fresh water resources of the country, of surface's and underground waters.
5. Warming has caused its impact on country climate and ecosystems. There is observed a decreasing of the water resources of the country, and thermal stress in the wetlands, lagoons and lakes of Albania. Impact it is observed first of all on the biodiversity.

5. The oceanographically situation in the Adriatic Sea is characterized from the formation of "The bridge" with continental water in the Adriatic Sea. "The bridge" is closely linked with the intensity of the river flow.

6. It is necessary to continued realizing, by a new project, of the analytical integrated studies of environmental impact of the global warming in Albanian territory and its consequences, carried out up to present, by the NGO Society "Protection and Conservation of the Albanian Inland and Coastal Waters".

6. Acknowledgments

Authors gratefully acknowledge the geothermal team colleagues of Geophysical Section in Faculty of Geology and Mining, Polytechnic University of Tirana, Geophysical Institute of Academy of Sciences in Prague, Well logging Enterprise in Patosi for the temperature logging. We express cordially thanks to the Çermak, V and Safanda, J. for the paleoclimate reconstruction of thermolots. Many thank to Institute of Meteorology of Academy of Sciences of Albania, and in particularly to the Dr. Vangjel Mustaqi for calculation of the annual average value of the meteorological data for the period 1985-2000.

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LIST OF CAPTIONS

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Fig. 2. Ground surface temperature history according to thermoplot of Ko-10 and Arza-31 wells (According to the Safanda, J. calculations).

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WORLD CLIMATE CHANGE CONFERENCE

MOSCOW, RUSSIA September 29-October 4, 2003

OUTLOOK ON PALEOCLIMATE CHANGES IN ALBANIA.

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ABSTRACT

In the paper there are presented the results of inversion of thermologs data for the ground surface temperature history in Albania. The analysis presented in paper is based on 4 thermoplots, from different regions of Albania. The wells are located in Sedimentary Basin of Albania, at the field region in the west of Central Albania and in the ophiolitic belt in the mountainous region of the northeast Albania. Based on inversion data, it results that 3.5 centuries ago in Western Albania the climate was warmer. Later a cooling of 1^{o}C occurred, until 1 century ago. During the 20th century an increase of 1^{o}C is observed. Inexpressive climate warming in the second half of this of this century is observed in Northwestern Albania. This warming mainly after the second half of the 20th century is presented also by meteorological data. The warming has caused its impact on country climate, water systems and ecosystems of the Albania.

Keywords: Ground Surface Temperature, Paleoclimate Changes, Paleoclimate Reconstruction, Thermolog,

INTRODUCTION

Albania lies in a subtropical zone. It is a Mediterranean country. Winter is relatively short and mild, humid near the seaside areas. Summer lasts very long and it is hot and dry. To the east, in the mountain areas, the climate is Mediterranean mountainous. There, the temperature is lower than in seaside zones and the raining decrease. Sunshine varies from 2560 hours per year in Tirana, down to 2046 hours in Kukesi City. Average yearly temperature varies from 16.5^{o}C in Vlora City, 11.8^{o}C in Kukes and 7.0^{o}C in the northern

area of the Albanian Alps. In Albania the rainfall is about 1430 mm a year. Albanian Alps is one of the most humid territory in Europe, up to 3094 mm a year rainfalls (Albanian Climate, 1978, Boriçi, M. and Demiraj, E. 1990, Mici, A. et al 1975).

The climate in Albania varies from a region to the other, according to the location compared with the seaside, to the seasons, years, and centuries. The ground temperatures are conditioned by geographical position of the area, area's geology, ground lithology, dynamics of the underground waters, meteorological conditions, and season.

The Albanides represents the assemblage of the geological structures in the territory of Albania. Two major peleogeographic domains form the Albanides: the Internal Albanides in the eastern part and the External Albanides in the western part of Albania. The Internal Albanides are characterized by presence of the immense and intensive tectonised ophiolitic belt, which is displaced from east to west as overthrust nappe. The External Albanides was developed out of the western passive margin and continental shelf of the Adriatic plate. The geological section of Albanian Sedimentary Basin is more than 12000 m thick.

The Earth crust in Albanides is interrupted by a system of longitudinal fractures in NW - SE direction and transversal fractures, that touch even the mantel. With deep fractures are linked geothermal energy of the Albanides.

Maximal geothermal gradient in this Basin has a value of 21.3 mK/m. These gradients change from one formation to others. Geothermal gradient increases up to 25 mK/m in the ophiolitic belt of the Inner Albanids. Heat flow density has its highest values of 42 $mW.m^{-2}$ in the Albanian Sedimentary Basin and 60 $mW.m^{-2}$ in ophiolitic belt (Cermak, V. et al 1996, Frasheri, A. and Cermak, V. et al. 1995, Frasheri, A. 1993, 1996).

Analyzing some thermoplots of different wells in Albania, it resulted a useful information to evaluate the paleoclimate changes until a thousand years ago. This information of the Ground Surface Temperature history, according to thermoplots in Albania, is analyzed in this paper.

MATERIAL AND METHODS

The study of geothermal field of Albania has been carried out based on the temperature logging in the oil and gas deep wells located in the Albanian Sedimentary Basin, also in boreholes in the ophiolitic belt. These wells, with a depth of 50 m to 6700 m, are located in different geological situations (Cermak, V. et al 1996, Frasheri, A. and Cermak, V. et al. 1995, Frasheri, A. 1993, 1996).

Paleoclimate reconstruction has performed by estimation of the ground surface temperature changes at the past T (z=0,t)=Ts (t), $-t_o \le t \le 0$, according to the present distribution of the temperature at the depth $T(z,t=0)=T^e(z)$, recorded in the borehole. Temperature distribution T (z, t) was evaluated by solving of the know problem (Dimitriev B.I. et al. 1997):

$$\frac{\lambda(z)}{a^2(z)} \times \frac{\partial T}{\partial t} = \frac{\partial}{\partial z}\left(\lambda(z)\frac{\partial T}{\partial z}\right) + j(z), \quad for\ -t_o \le t \le 0,\ 0 \le z \le H,$$

$$T_z(z,t=-t_o) = T_{St}(z),$$

$$T(z=0,t) = T_S(t),\ T_S(t=-t_o) = T_{St}(z=0) = T_o,$$

$$\lambda\frac{\partial T}{\partial z}\Big|_{z=H} = q,$$

$$\left[T_{St}\right]_{z_n} = 0,\ \left[\lambda\frac{dT_{St}}{dz}\right]_{z_n} = 0$$

Where: temperature-conductivity coefficient $a^2(z)$, heat-conductivity $\lambda(z)$ and heat sources j(z) are changes with the depth $0<z<\infty$. The parameters a(z), $\lambda(z)$, j(z), and heat flow density (q) at the depth must be determined by measurements. The beginning temperature distribution function $T_{St}(z)$ is determined by a condition of $T(z,t=0)=T^e(z)$.

Ten thermoplots were used for inversion of the ground surface temperature history. For the analysis presented in this paper we have chosen 4 thermoplots, in different regions of Albania. Well Ko-10 it is located in Sedimentary Basin of Albania, at the field region in the west of Central Albania (Fig. 1). Wells Vl-1127, Gurth-595, Krasta-1 and Ragam-168 are located in the ophiolitic belt, in the mountainous region of the northeast of the Albania. The temperature inversion for paleoclimate reconstruction done by Dr. V. Cermak and Dr. Jan. Safanda (Vl-1127, Gurth-595, Krasta-1, Ragam-168) and Prof. Henry Pollack (Ko-10 well), using Dr. P. Z. Shen software program, adopted after GST inversion technique proposed (Frasheri, A. 1995, Frasheri, A., Cermak, V. and Safanda, J 1999).

The results of this inversion of the ground surface temperature history are correlated with the data of air and ground temperatures, which are recorded in Meteorological Stations (1, 2, 9, 10). In the event of not being able to make a full comparison of the whole time of the ground surface temperature history, we consider this test as valuable also for the last decades, for which there are hydrometereological instrumental data. For this correlation three stations are chosen Tirana in Central Albania, Fier at Western area and Kukes in Northwestern region of Albania (Tab; 1; Fig. 1) (Albanian Climate, 1978, Boriçi, M. and Demiraj E. 1990, Gjoka, L. 1990, Mici, A. et al 1975, the data for 1985-2000 after Mustaqi V.).

Location of the Meteorological Stations Tab 1

Station	Coordinates		Altitude (m)	Area
	φ_N^o	λ_E^o		
Tirana Airport	41° 20’	19° 47’	88.9	Central Albania
Kukesi	42° 25’	20° 25’	354.2	North-Eastern Albania
Fieri	40° 44’	19° 31’	12.0	Western Albania

RESULTS AND DISCUSSION

The thermoplot of Kolonja-10 deep well, which is located in field's Western region of Albania, temperature trend and residual temperature anomalies are shown in fig. 2 (Frasheri, A. 1995).

According to these data, climate reconstruction of the thermal field is presented in fig. 3. As it is seen in this figure, from the beginning of the 20^{th} century the seaside region of Albania is warmer. The average increase in the temperature is about 1 ^{o}C. To the contrary, from the XV^{th} century until the end of XIX^{th} it has cooled about 1^{o}C. Pre-1500 Mean Ground Surface Temperature is equal to the To=17.9 ^{o}C. First five centuries of the second millenium are characterized by a warming of 1^{o}C. In this way, climate in the seaside field's part of Albania is characterized by increase and decrease alternations of the temperature. These alternations have lasted for five centuries. Change of the average yearly temperature has not been over 1^{o}C.

Fig. 4,5 shows a GST history according to Vl-1127, Gurth-595, Krasta-1 and Ragam-168 boreholes, which are located in the mountainous regions of Northeast Albania. Some nonessential changes are observed in these regions as to the warming trend of the 20^{th} century.

To correlate data of GST history according to geothermal studies with the data of hydrometeorological observations, there are analyzed data from three stations that we had in disposition. These stations are located in field regions (Tirana and Fier) and in mountainous regions of Albania (Kukes), where the investigated wells are situated. Fig. 6 presents graphics of yearly average temperature of the air and ground at depth of 20 cm and 40 cm in Tirana Meteorological Station. As well known, Tirana is located in Central Albania. During 1985-2000 there is presented only the average annual air temperature, because of lack of data of the soil temperature (fig. 7). In general, by the end of 20^{th} century, in all Albania is observed a warming of climate. Warming trend it is observed in the air and the soil in all Albanian territory (Fig. 7, 8). The warming trend, in particular

after seventy years, clearly shows these graphics**.** The meteorological data shows that the warming trend is not a monotone one. In short intervals are observed cooling and warming (Fig. 8). The meteorological studies have verified this phenomenon, too. It has been consisted that: “Around the 1980’s a warming trend is observed” (2, 8). The warming period, in the field regions of Albania, is accompanied with a decrease in the rainfalls (Fig. 9).

This warming is part of the global Earth warming during the second half of XX century. Its impact has been observed in some directions. There are two main directions:
Firstly, with decaying of the rainfalls is observed decreasing of the water resources of the country, of surface’s and underground waters.
Secondly, temperature augmenting has caused increasing of the evaporation in the water systems. Consequently in the river system, reservoirs, wetlands, lakes and lagoon system has been observed thermal stress. In very beautiful ecosystems of Albanian lagoon as Narta, Karavasta, Kune-Vaini and Micro Prespa Lake etc. thermal stress has its impact, first of all on the biodiversity.

CONCLUSIONS

Based on the results of inversion of the thermologs data, recorded in deep wells and boreholes, for the evaluation of the ground surface temperature GST history, we have arrived in following conclusions:

1. The climate in Western field’s regions of Albania was warmer 3.5 centuries ago. Later a cooling of 1^{o}C occurred, until 1 century ago. During the 20th century an increase of 1^{o}C is observed.
2. Temperature records in Northwestern Mountainous region of Albania confirmed inexpressive climate warming in the second half of this of this century.
3. This warming, mainly after the second half of the 20th century, is demonstrated also by meteorological data.

4. Warming has caused its impact on country climate and ecosystems. There is observed a decreasing of the water resources of the country, and thermal stress in the wetlands, lagoons and lakes of Albania. Impact it is observed first of all on the biodiversity.

ACKNOWLEDGMENTS

Authors gratefully acknowledge the geothermal team colleagues of Geophysical Section in Faculty of Geology and Mining, Polytechnic University of Tirana, Geophysical Institute of Academy of Sciences in Prague, Well logging Enterprise in Patosi for the temperature logging. We express cordially thanks to the Prof. Henry Pollack, Dr. Vladimir Çermak and Dr. Jan Safanda for the paleoclimate reconstruction of Ko-10 depth well, Vl-1127, Gurth-595, Krasta-1 and Ragam-168 boreholes. Many thank to the Dr. Vangjel Mustaqi for calculation of the annual average value of the meteorological data for the period 1985-2000.

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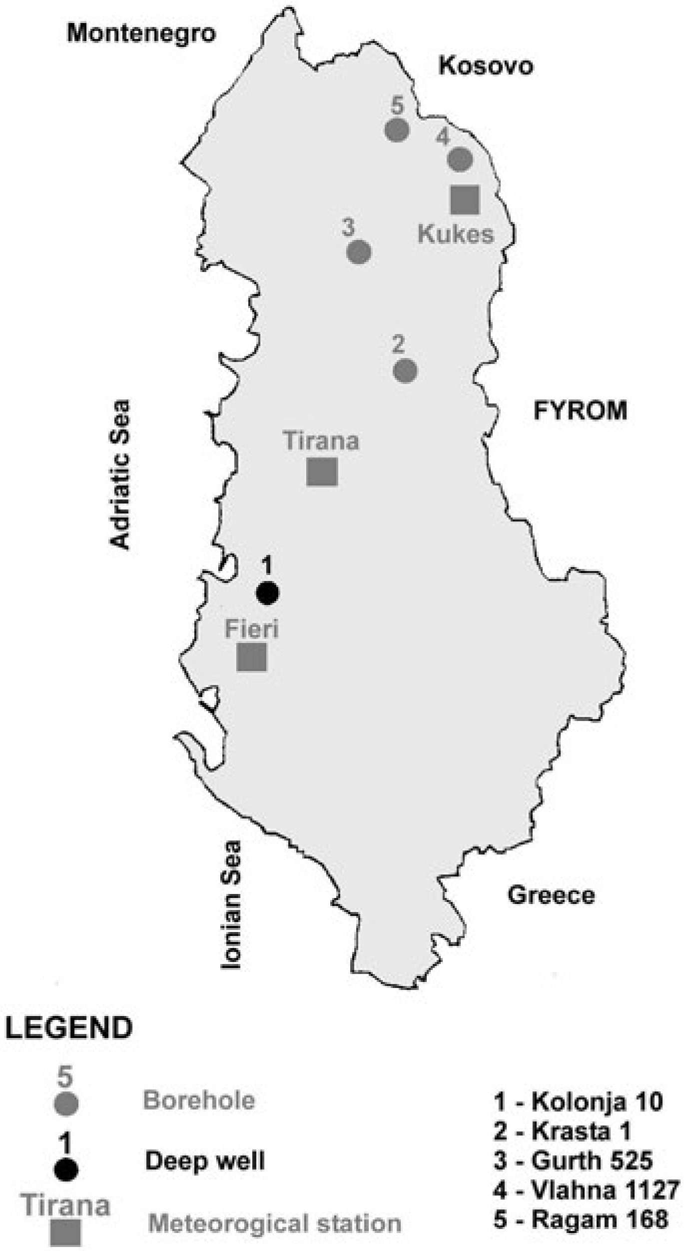

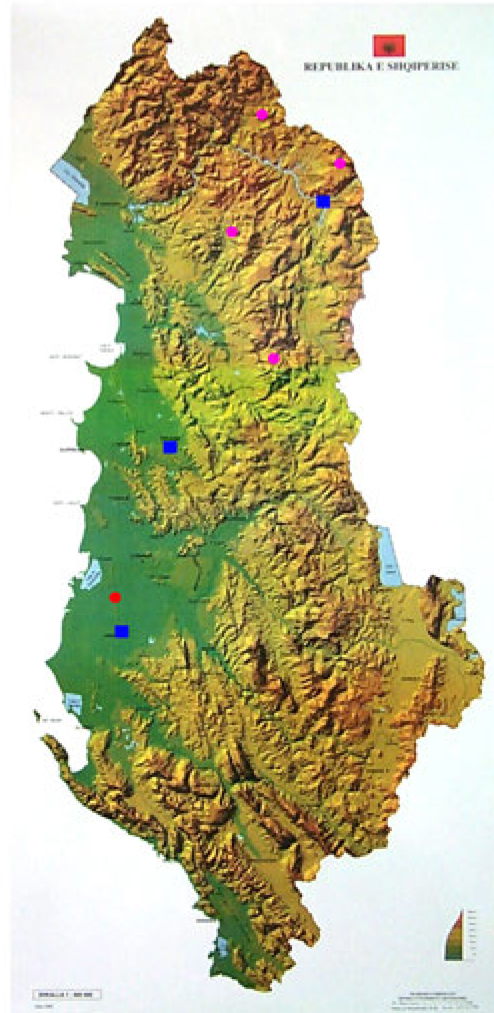

Fig. 1. Map of Albania and location of the Kol-10, Vl-1127, Gurth-595, Krasta-1 and Ragam-168 wells and Tirana, Fier and Kukes Meteorological Stations.

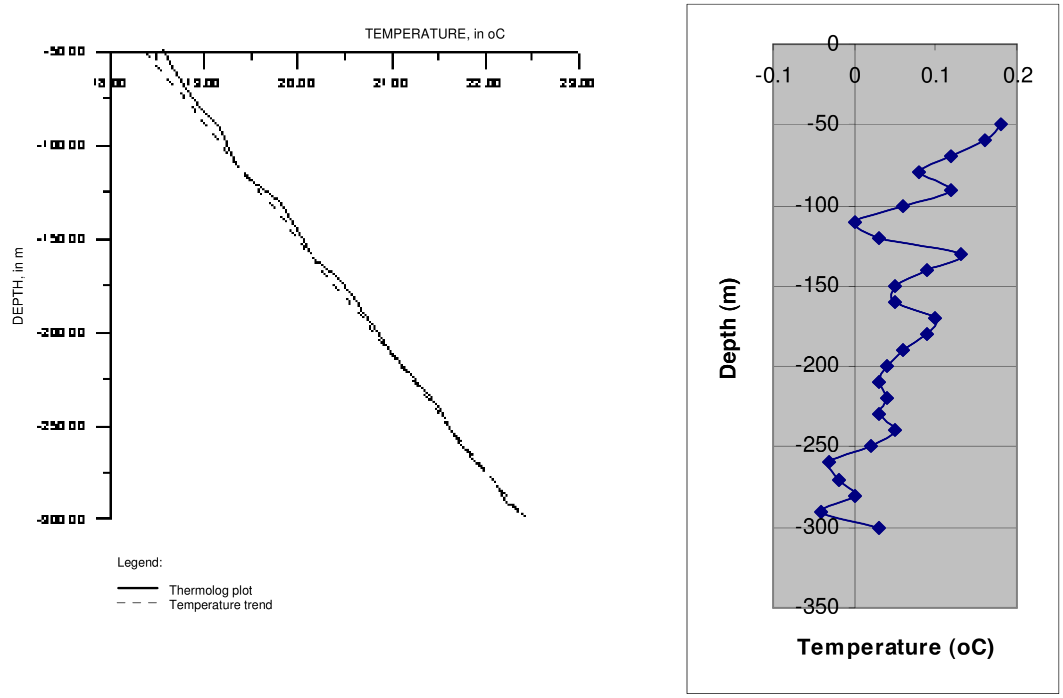

Fig. 2. Thermoplot of Ko-10 well in field Western region of Albania.

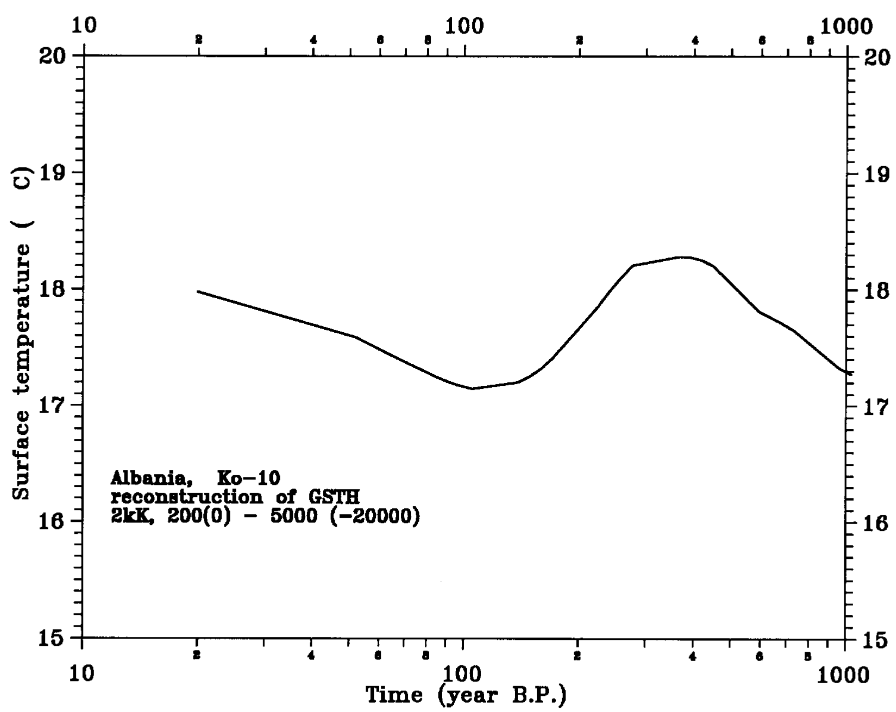

Fig. 3. Ground surface temperature history according to thermoplot of Ko-10 well (according to the Prof. H. Pollack calculations)

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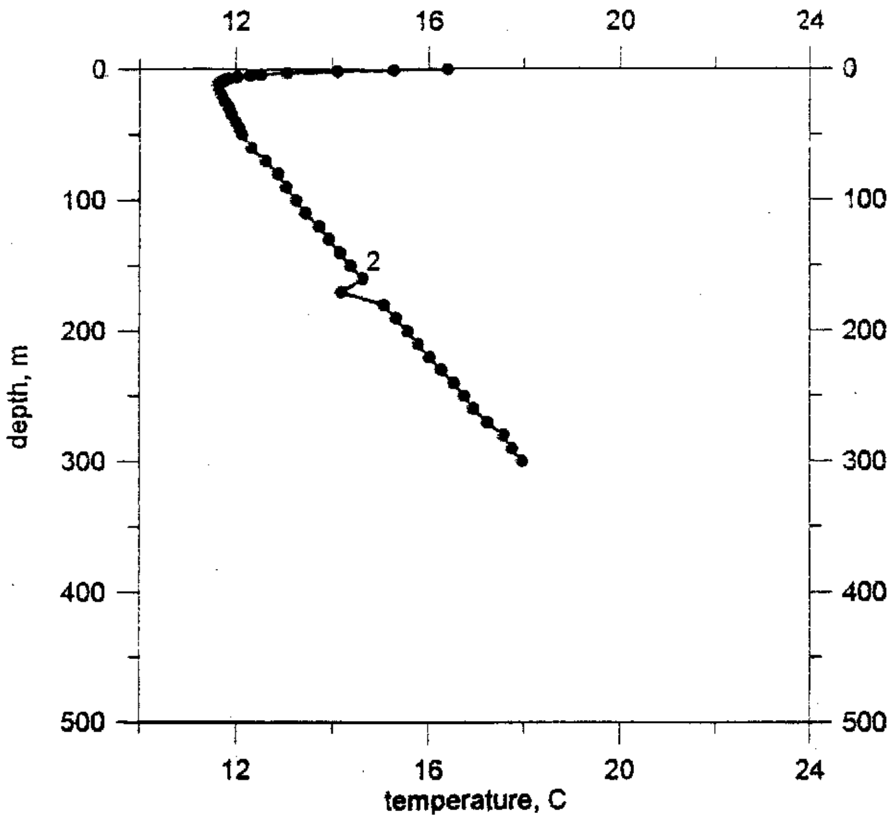


Fig. 4. Thermolog of Vl.-1127 borehole, located in mountainous northwestern region of Albania

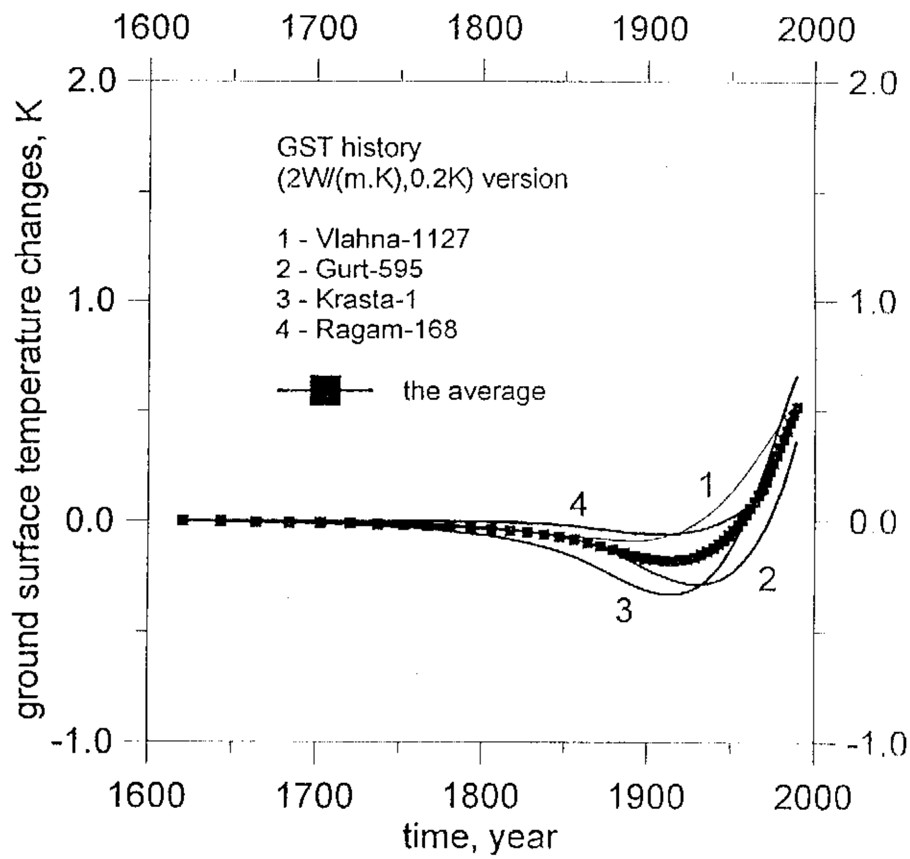


Fig. 5. Ground surface temperature history according to thermoplot of Vl.-1127, Gurth-595 and Krasta-1 boreholes (According to the Dr. Cermak, V. and Dr. Safanda, J. calculations).

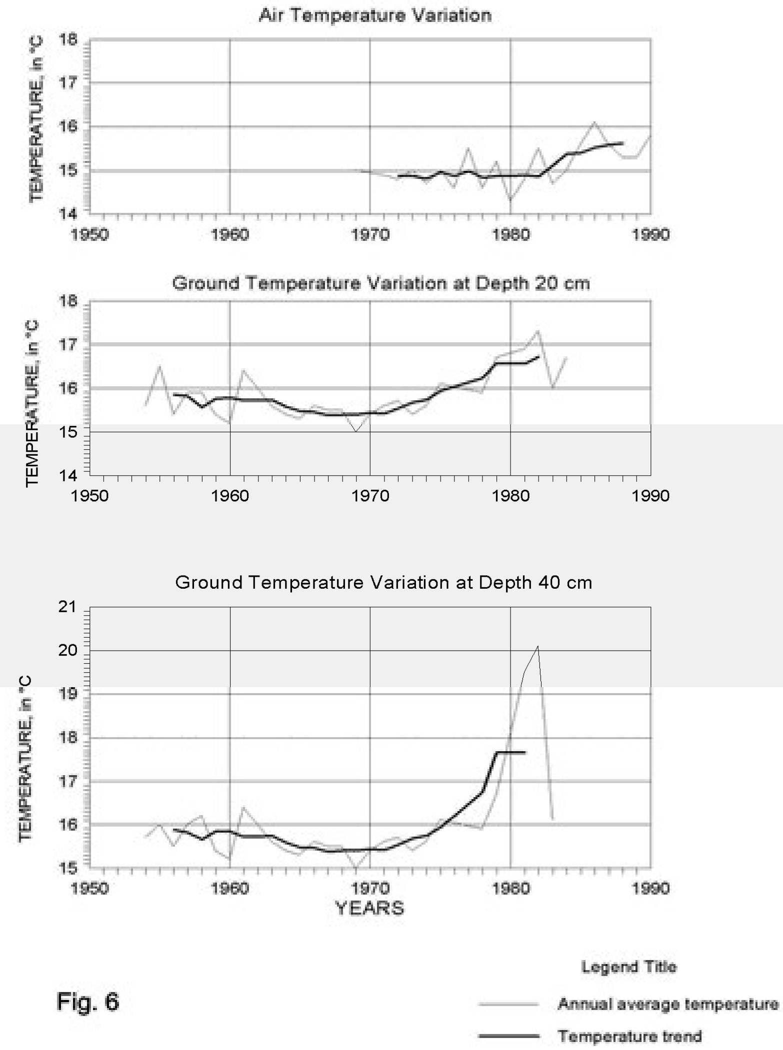


Fig. 6. Air and Ground Average Annual Temperature Variation at Tirana Meteorological Station.

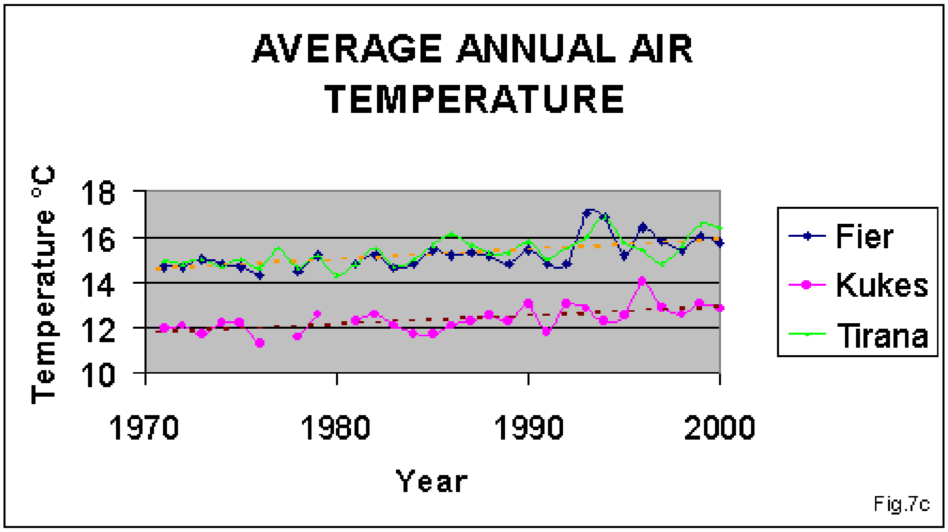


Fig. **7**. Air Average Annual Temperature Variation at Tirana, Kukes and Fier Meteorological Stations.

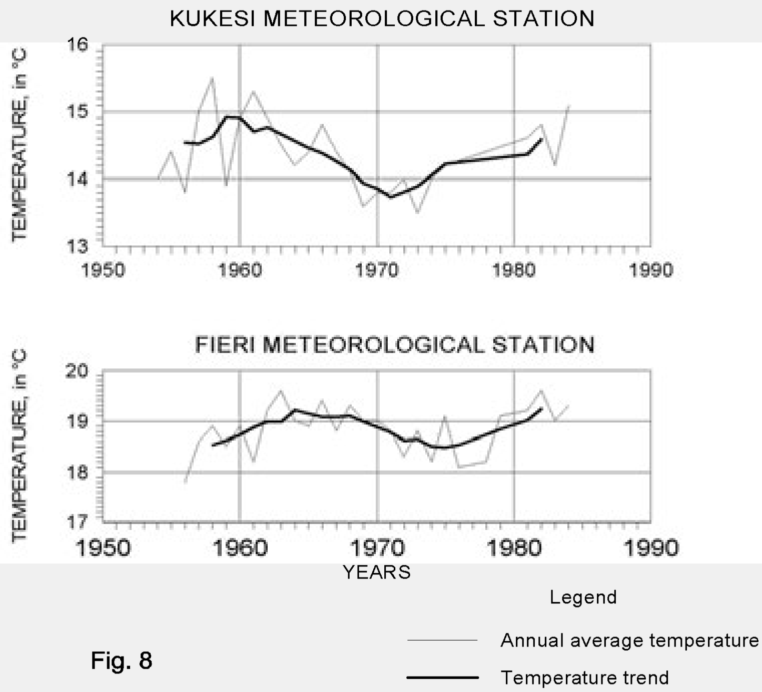


Fig. 8. Ground Surface Average Annual Temperature variation at Kukes and Fier Meteorological Stations.

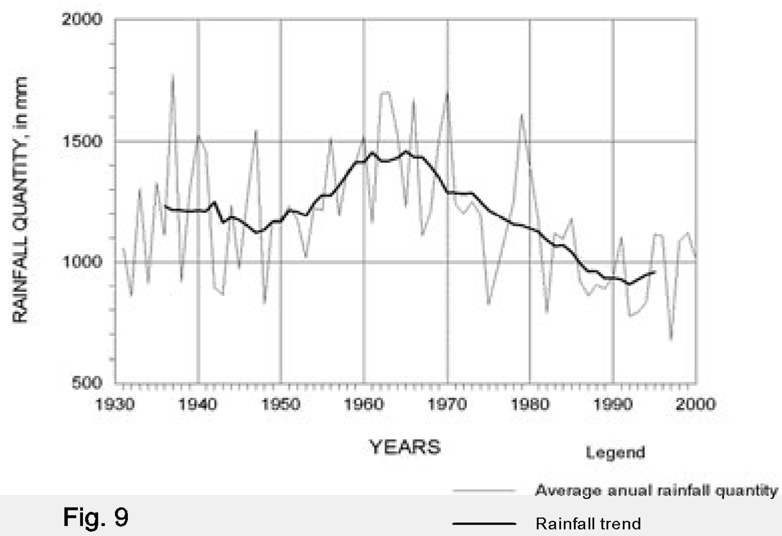
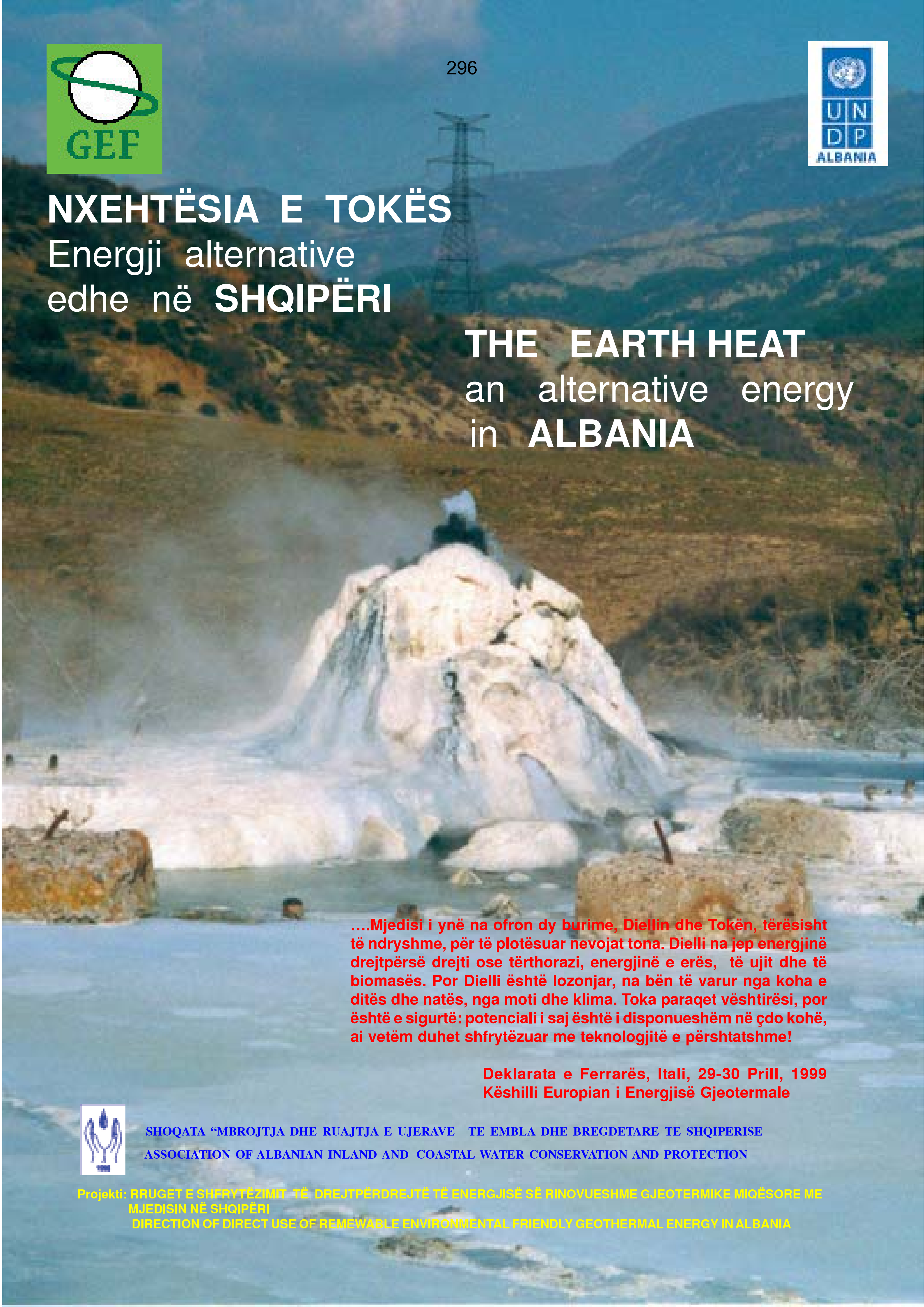


Fig. 9

Fig. 9. Average Annual Rainfall Quantity, Tirana Meteorological Station.



NXEHTËSIA E TOKËS
Energji alternative edhe në SHQIPËRI

THE EARTH HEAT
an alternative energy in ALBANIA

....Mjedisi i ynë na ofron dy burime, Diellin dhe Tokën, tërësisht të ndryshme, për të plotësuar nevojat tona. Dielli na jep energjinë drejtpërsë drejti ose tërthorazi, energjinë e erës, të ujit dhe të biomasës. Por Dielli është lozonjar, na bën të varur nga koha e ditës dhe natës, nga moti dhe klima. Toka paraqet vështirësi, por është e sigurtë: potenciali i saj është i disponueshëm në çdo kohë, ai vetëm duhet shfrytëzuar me teknologjitë e përshtatshme!

Deklarata e Ferrarës, Itali, 29-30 Prill, 1999
Këshilli Europian i Energjisë Gjeotermale

SHOQATA "MBROJTJA DHE RUAJTJA E UJERAVE TE EMBLA DHE BREGDETARE TE SHQIPERISE

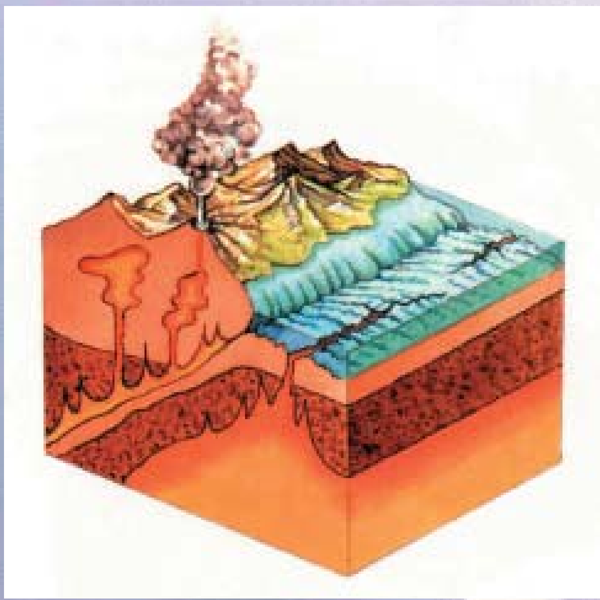
ASSOCIATION OF ALBANIAN INLAND AND COASTAL WATER CONSERVATION AND PROTECTION

Projekti: RRUGET E SHFRYTËZIMIT TË DREJTPËRDREJTË TË ENERGJISË SË RINOVUESHME GJEOTERMIKE MIQËSORE ME MJEDISIN NË SHQIPËRI
DIRECTION OF DIRECT USE OF REMEWABLE ENVIRONMENTAL FRIENDLY GEOTHERMAL ENERGY IN ALBANIA

TOKA - KY PLANET I NXEHTË!

Sipërfaqja e Tokës është dëshmitare e shfaqjes, shpesh herë të fuqishme e brutale, të energjive të brendshme të Planetit. Këto energji grupohen në dy kategori:

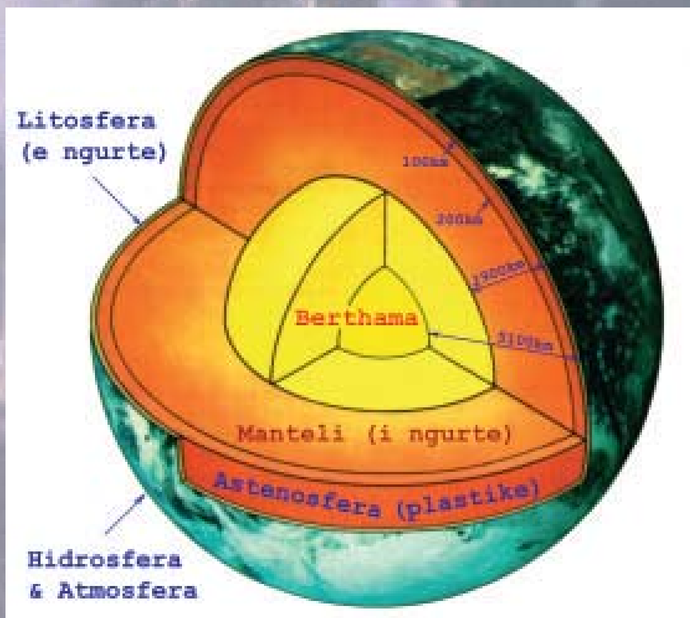
Energjia mekanike e tërmeteve dhe Energjia termale e vullkaneve

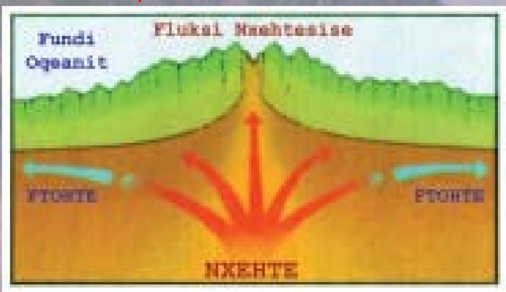


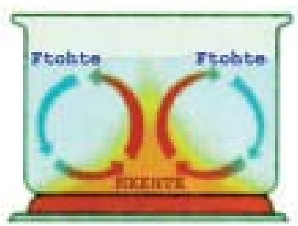
Geizer në Zelandën e Re
(Sipas W.A. Elders)

Vullkanet dhe geizeret
janë dëshmi të energjisë së madhe termike të Tokës.

Toka është një planet i nxehtë. Në qendër të saj, përllogaritet që temperatura të jetë rreth 4000°C. Fluksi i nxehtësisë, që vjen nga thellësitë në sipërfaqen e Tokës luhatet mesatarisht nga 54.4 mW/m^2 në kontinente, deri 67 mW/m^2 në oqeane. Planeti shpërndan në sipërfaqe një sasi nxehtësie që arrin deri 42 miliardë kilowat.







Nga thellësitë e nëntokës fluksi i nxehtësisë drejtohet për në sipërfaqen e Tokës

Toka ka burimet e veta, të cilat gjenerojnë nxehtësi:

- të mbetur nga koha e formimit të planetit (26-52% e totalit),
- të çliruar nga zbërthimi i elementëve radioaktivë që përmban lënda e Tokës (22-47%),
- të çliruar nga kristalizimi i mineraleve dhe nga diferencimi gravitativ i lëndës (4.7-9%),
- të çliruar gjatë lëvizjeve tektonike dhe tërmetet (0.8%).

Mesatarisht, temperatura e Tokës rritet me thellësinë sipas një shkalle gjeotermike Sh= 1°C çdo 32 m, duke patur një gradient gjeotermik 3.12 °C/100m.

ENERGJIA GJEOTERMALE

Sistemi energjetik:

1. Lëndë djegëse: - Të ngurta (Qymyr guri dhe torfa)
   - Të lëngëta (Nafta)
   - Të gazta (Gazi djegës)
2. Energjia termobërthamore
3. Energjitë e rinovushme (energji të bardha, ekologjike): - E ujit
   - E biomasës
   - Gjeotermale
   - E Diellit
   - E erës

Në vendet e përparuara Europiane është intensiv shfrytëzimi i energjive të rinovueshme, miqësore me mjedisin. Aktualisht, p.sh. në Zvicër, prodhimi i energjive nga burime të ndryshme, është si më poshtë:

- Energjia e biomasës (druri) 5720 GWh, ose 81.5 % e totalit
- Gjeotermale 618 GWh, ose 8.7%
- Energjia e Ajrit dhe ujit 412 GWh, ose 5.8%

Energjia gjeotermale merret nga nxehtësia e çliruar nga:

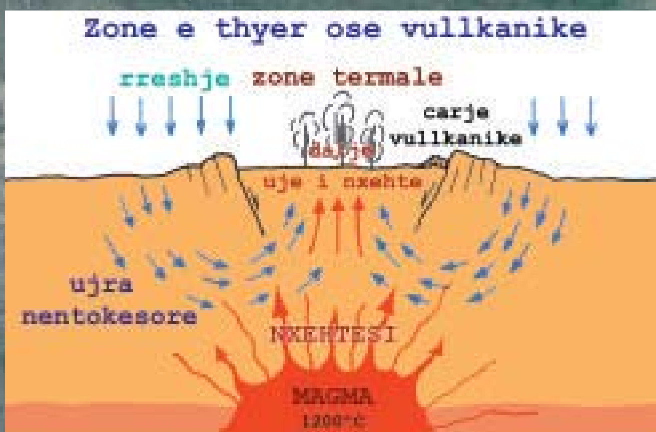
1. **Shkëmbinjtë e thatë, me anën e Këmbyesve Vertikalë të Nxehtësisë në shpime,**
2. **Ujërat termale të cilët kategorizohen:**

Entalpia e lartë. Fumarola (avulli dhe uji shumë i nxehtë) që shpërthen në sipërfaqe përbëhet nga ujë i valuar dhe avuj me temperatura të larta, që arrijnë deri në 310°C në rezervuarin nëntokësor. Tipikë janë geizeret, midis të cilëve është i famshmi “Gejzeri” i Islandës. Shatërvani i ujit në geizerë arrin deri 40-42 m lartësi dhe ai i avullit deri 150 m.
Entalpia e mesme. Fluidi (uji dhe avulli) gjeotermal ka temperaturë që luhatet nga 80°C deri në 150°C.
Entalpia e ulët. Uji del në sipërfaqe në formën e burimeve, ose me anën e shpimeve. Ka burime me ujë të ngrohtë (27°C-37°C), me ujë të nxehtë (37°C - 42°C) dhe shumë të nxehtë (42°C deri 80°C).

Energjia gjeotermale e entalpisë së lartë shfrytëzohet:

1. Kryesisht për prodhimin e energjisë elektrike. Në vitin 2000 fuqia e instaluar ka qenë 9 960 MWe, në nivel botëror.
2. Për ngrohje, në industri dhe në bujqësi.

I famshmi “**GEJZER**” në Islandë
(Foto- ORKUSTOFNUN)



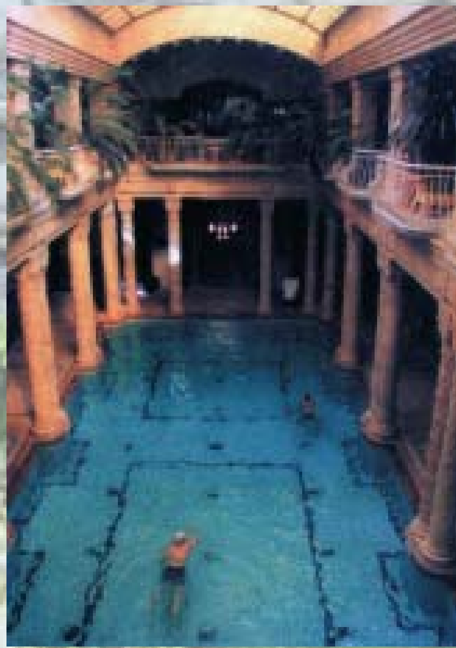
Uji i rreshjeve atmosferike përshkon shkëmbinjtë nëpërmjet poreve e çarjeve të tyre dhe futet në thellësi të mëdha. Atje, ngrohet nga nxehtësia që merr nga shkëmbinjtë, të cilët janë burimi parësor i energjisë gjeotermale dhe mbas kësaj, kryesisht, nëpërmjet thyerjeve tektonike del në sipërfaqe, në formën e burimeve ose të geizerëve. Këta janë burimet dytësore të nxehtësisë.

PERDORIMI I DREJTPËRDREJTË I ENERGJISË GJEOTERMALE NË BOTË
WORLD-WIDE DIRECT USE OF GEOTHERMAL ENERGY

Energjia gjeotermale shfrytëzohet edhe drejtpërsë-drejti, gjerësisht në shumë fusha të veprimtarisë jetësore dhe ekonomike. Në nivel botëror, në vitin 2000 fuqia e instaluar për shfrytëzimin e drejtpërdrejtë të kësaj energjie, ka patur këtë strukturë:

- Për ngrohje me pompa nxehtësie	6 849 MW
- Për ngrohjen e godinave me ujë të nxehtë	4 954
- Për klinika dhe pishina për banjë dhe notim	1 796
- Për ngrohjen e serave	1 371
- Për akuakulturë	525
- etj	....
Total	16 209 MW

Në vendet fqinjë të Europës jugë-lindore, energjia e përdorur është (në GWh/vit): Itali 1048 , Rumani 797, Bullgari 455, Kroaci 154, Slloveni 196,



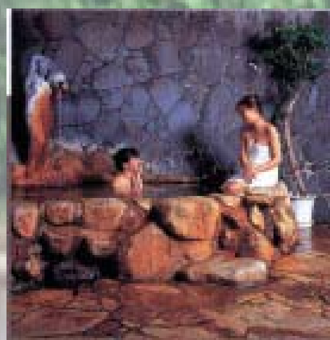
Pishinë termale. Hotel Budapest (Foto Prof. J.W.Lund)

Përdorimi i drejtpërsëdrejti i energjisë gjeotermale është shumë i larmishëm:

Së pari, *përdorimi i ujit të nxehtë të burimeve dhe puseve*.

Përdorimi klasik i ujërave termale në të kaluarën ka qënë i kufizuar. Ato janë shfrytëzuar vetëm për kurimin e sëmundjeve të ndryshme në të ashtuquajturat "Llixha". Por në çerek shekullin e fundit u bë një ndryshim në koncept. Sot, ujërat termale konsiderohen se janë të dobishme dhe duhen përdorur gjerësisht për kalitjen e shëndetit të njerëzve të shëndoshë dhe për dëfrimin e tyre, që janë edhe shumica e popullsisë, si edhe për kurimin e sëmundjeve. Prandaj ndërtohen dhe shfrytëzohen hotele turistike me pishina dhe banja me ujë të ngrohtë, krahas klinikave të "Llixhave".

Southampton Grand Hotel, Angli (Foto M. Smith)



Hotel Arthur Beppu, Japoni

Ngrohja e serave për prodhimin e luleve dhe të perimeve është një nga drejtimet e rëndësishme të përdorimit të energjisë gjeotermale.

Serë (ORKUSTOFUN, Islandë)

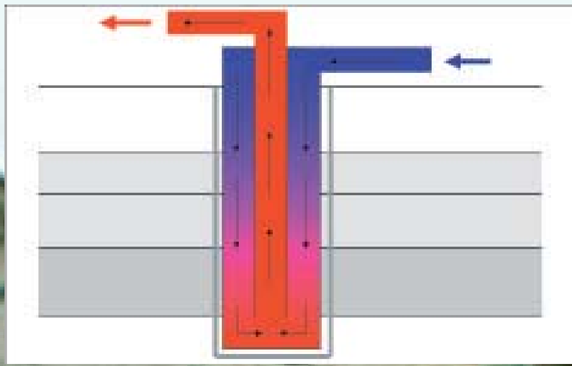
Nxjerrja e mikroelementëve dhe kripërave natyrore nga ujërat termale minerale është një veprimtari ekonomike me shumë vlerë.

Fermë për rritje rrasati peshku (ORKSUSTOFUN- Islandë)

Me ujin e nxehtë ngrohen edhe basene ujore për rritjen e rasatit të peshqve , si edhe për rritjen e algave të ndryshme.

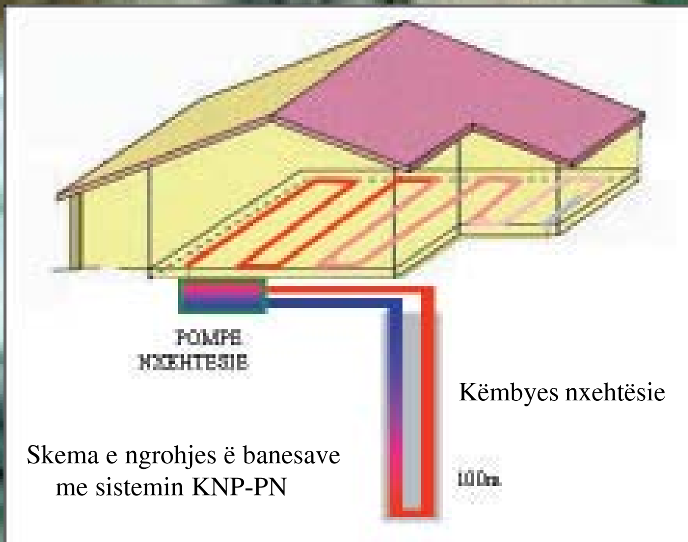
Me kripërat dhe nga alget prodhohen edhe pomada, nga më të mirat, për kurimin e sëmundjeve të ndryshme të lëkurës dhe për kozmetikë.

Së dyti, përdorimi i puseve të thellë të naftës dhe gazit të braktisur, çift ose të vetmuar për të shfrytëzuar energjinë gjeotermike, si “Burime vertikale drejtvizore nxehtësie”. Në puse të vetmuar mund të instalohen sisteme të mbyllur qarkullues së ujit të ftohtë për t’u ngrohur në thellësi. Me anën e konveksionit , uji ngrohet nga nxehtësia e shkëmbinjve. Ai mund të përdoret për ngrohjen e serave dhe të banesave.



Burim drejtvizor vertikal nxehtësie

Së treti, përdorimi i sistemit Këmbyes Nxehtësie-Pus (KNP)-Pompë Nxehtësie (PN) për ngrohjen e banesave. Aktualisht këto janë sistemet më moderne, me teknologji më të përparuar , miqësore me mjedisin dhe po bëhen gjithnjë e më shumë popullore. Në shumë vende të Komunitetit Europian bëhen përpjekje të mëdha për të reduktuar varësinë e tyre nga karburanti i importuar për ngrohje. Burimet vendore të energjisë , siç është nxehtësia e shtresave pranësipërfaqsore janë veçanërisht në fokus, edhe për përparësite e tyre, lidhur me efektivitetin e lartë ekonomik, si edhe për mbrojtjen e mjedisit nga efekti serë, i shkaktuar nga



Skema e ngrohjes ë banesave me sistemin KNP-PN

Blok banesash komunale, Hollandë
Sipërfaqja e ngrohur 7900 m^2

Godine institucionale, Lion, Francë
sipërfaqja e ngrohur 1600 m . Kosto e energjise eE/vit.m^2

Në 26 shtete, deri më sot janë montuar 570 000 instalime BHE-HP, më fuqi 12 KW secila, për ngrohjen dhe freskimin e shtëpive-vila, por ka edhe mijëra instalime me fuqi deri 500 KW që shërbejnë për ngrohjen e institucioneve dhe të blloqeve të banesave komunale. Shembull tipik është Zvicra, ku ka 21 000 instalime , me fuqi të pompës nga 19-40 KW, të cilët shfrytëzojnë nxehtësinë e shtresave pranësipërfaqsore të tokës me temperaturë rreth 10°C. Nëse, p.sh., në vitin 1980 prodhimi i energjisë gjeotermale nga këto sisteme në Zvicër ka qënë 70 GWh, në vitin 1999 ai arriti në 365 GWh .

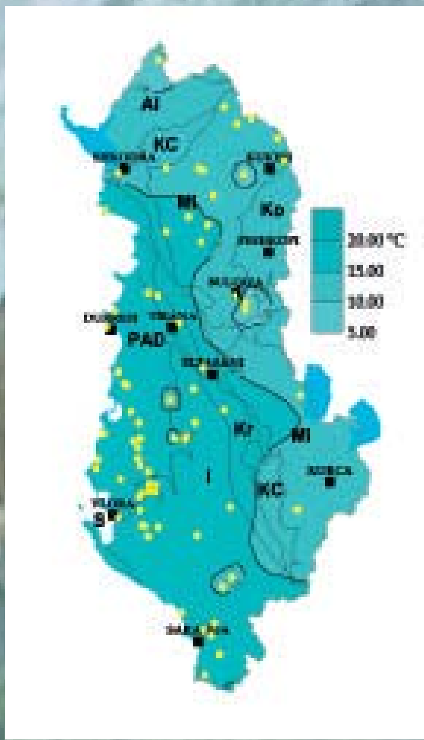
RREGJIMI GJEOTERMAL I ALBANIDEVE
GEOTHERMAL REGIME OF THE ALBANIDES

Temperatura

Fusha gjeotermale karakterizohet nga temperatura relativisht të ulëta. Në thellësinë 100 m temperaturat luhaten nga 8°C deri 20°C. Temperatura arrin deri 68°C në thellësinë 3000 m në rajonin e Myzeqesë. Në thellësinë 6000 m temperatura arrin 105.8°C. Temperatura më të ulëta janë regjistruar në rajonet malore të vendit.

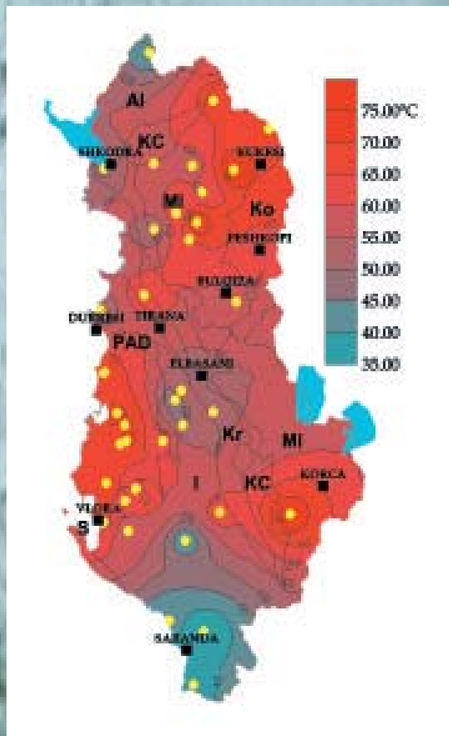
Temperature

Geothermal field is characterized by relatively low values of temperature. The temperature at 100 meters depth varies from 8 to 20°C. The highest temperatures (up to 68 °C) at 3000 meters depths have been measured in plane regions of western Albania. At 6000 meters depth, the temperature is 105.8°C. The lowest temperature values have been recorded in mountain regions.



Harta e Temperaturës në thellësi 100 m

Temperature Map at depth 100 m



Harta e Temperaturës në thellësi 3000 m

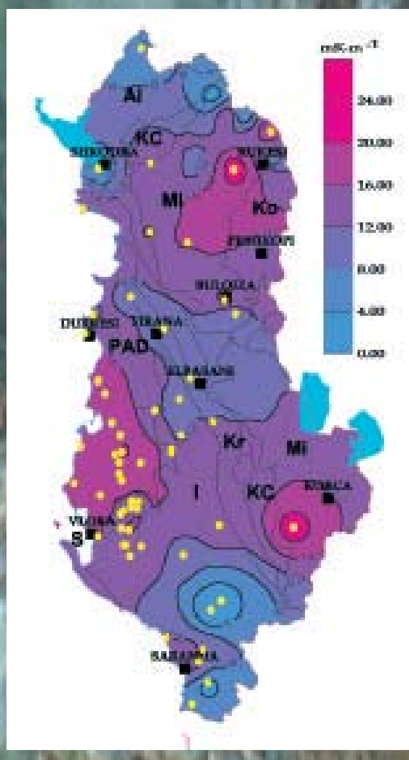
Temperature Map at depth 3 000 m

Gradienti gjeotermal

Temperatura rritet me thellësinë sipas një gradienti gjeotermal prej 2,13°C/100m në prerjen gjeologjike argjilore të Pliocenit në rajonin e Myzeqesë. Gradienti gjeotermal arrin vlera deri 3.6°C/100m në brezin e shkëmbinjve magmatikë në zonën tektonike Mirdita, veçanërisht në Shqipërinë jug-lindore, pranë kufirit shtetëror shqiptaro-grek..

Geothermal Gradient

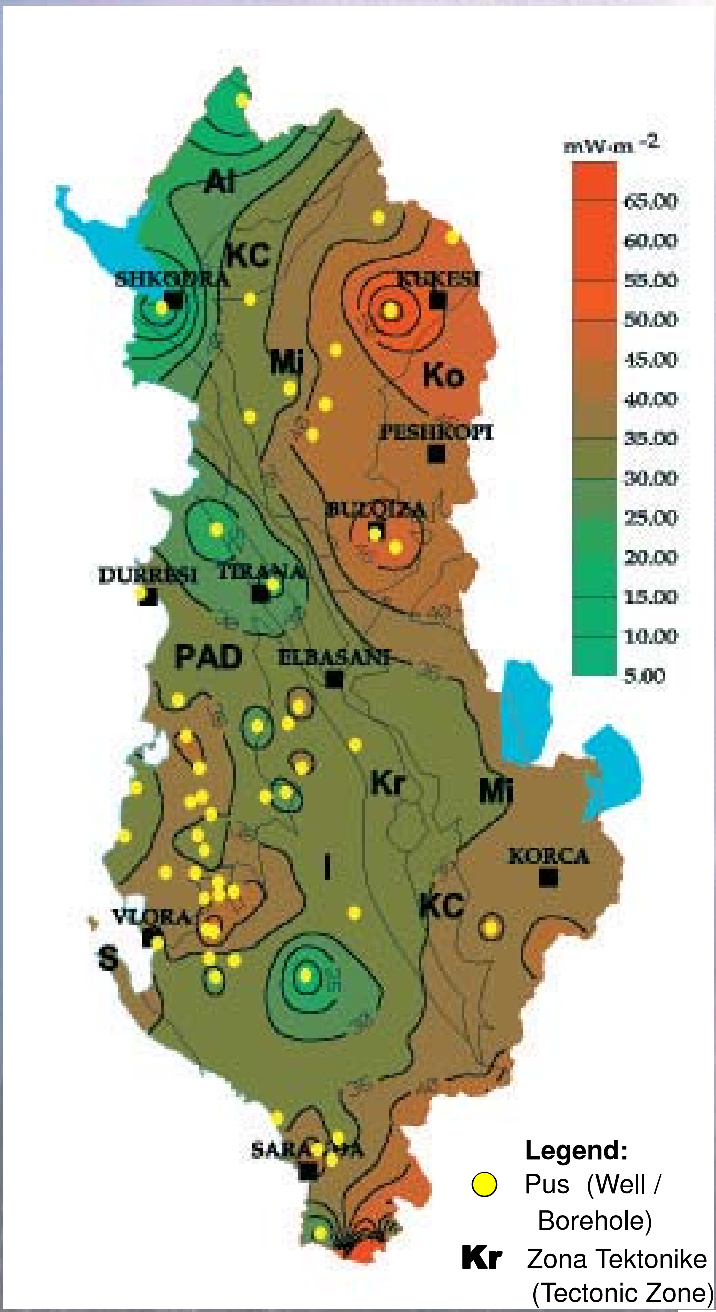
The geothermal gradient displays the highest value of about 2.13°C/100m in the Pliocene clay section at center of Pre-Adriatic Depression. In the ophiolitic belt of Mirdita tectonic zone, the geothermal gradient values increase up to 36 $mK.m^{-1}$, especially in southeastern Albania, towards the Albanian - Greek border.



Harta e Gradientit Gjeotermal

Geothermal Gradient Map

HARTA E DENDESISE SE FLUKSIT TERMIK
HEAT FLOW DENSITY MAP



Dendësia e Fluksit të Nxehtësisë

Përhapja e fluksit të nxehtësisë në territorin shqiptar paraqet dy veçori:

Së pari, vlera më e madhe e fluksit në rajonet fushore të Myzeqesë është 42 mW/m². Madhësia e dendësisë së fluksit të nxehtësisë arrin deri 60 mW/m² në brezin e shkëmbinjve magmatikë në zonën tektonike Mirdita.

Së dyti, në brezin e shkëmbinjve magmatikë vrojtohen disa vatra me dendësi më të lartë të fluksit të nxehtësisë. Këto vatra janë të shkaktuara nga transmetimi intensiv i nxehtësisë nëpërmjet thyerjeve të thella tektonike gjatësore e tërthore. Thyerjet tektonike kushtëzojnë edhe vendosjen e burimeve të energjisë gjeotermale, në thellësi rreth 8-12 km, ku temperatura arrin deri 220°C.

Heat Flow Density

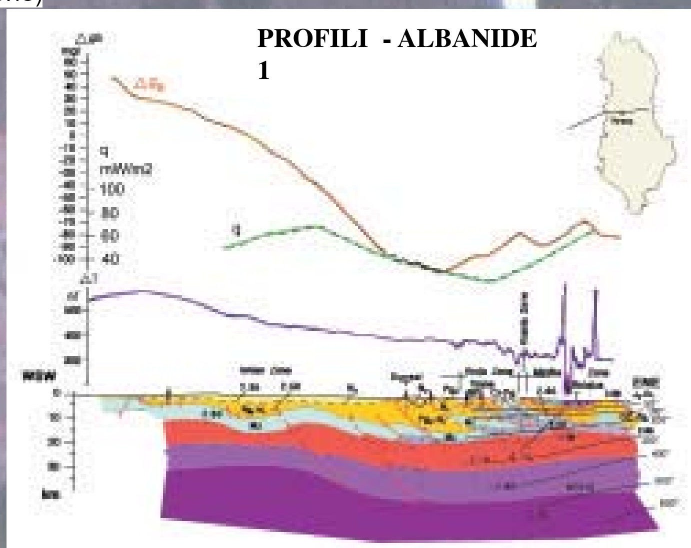
The regional pattern of heat flow density in the Albanian territory is presented by two particularities:

Firstly, the maximal value of heat flow is equal to 42 mW/m² in External Albanides. In the ophiolitic belt at eastern part of Albania, the heat flow density values range up to 60 mW/m².

Secondly, in the ophiolitic belt there are observed some hearths of higher heat flow density. Heat flow anomalies are conditioned by intensive heat transmitting through deep and transversal fractures. These fractures are conditioned location of the geothermal energy sources. According to the different geo-thermometers calculations, the aquifer estimated temperatures are 144°C to 270°C. Based on the geothermal modeling, it is supposed that thermal waters rises from 8-12 km deep, where temperature attains to 220°C.

Sipas profilit krahinor Albanide-1 rezulton se granitet e bazamentit kristalin në zonën Mirdita janë burimi radiogjen i nxehtësisë, që ka shkaktuar zmadhimin e fluksit të nxehtësisë.

According to the Albanides-1 regional section, it rasults that the crystal basement granite, have great possibilities to be radiogenic heat source, increasing heat flow density.



ZONAT GJEOTERMALE DHE REZERVUARËT E UJËRAVE TERMALË NË SHQIPËRI
GEOTHERMAL ZONES AND THERMAL WATER RESERVOIRS IN ALBANIA

Në Shqipëri ka shumë burime dhe puse të ujërave termale të entalpisë së ulët. Ujërat e tyre kanë temperatura që arrijnë deri 65.5 °C (Fig. 1, Tab. 1).

In Albania there are many thermal springs and wells of low enthalpy. Their water has temperatures that reach values of up to 65.5°C (Fig. 1, Tab.1).

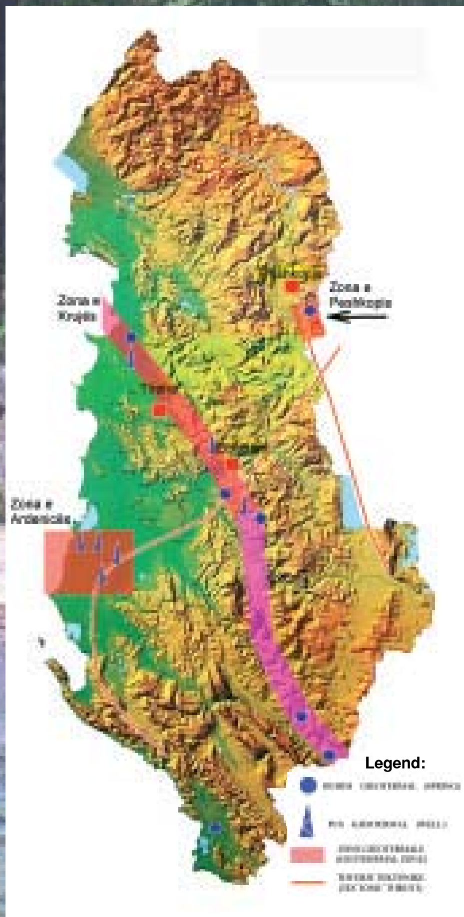
Tab.1

Burimet dhe puset e ujërave termalë në Shqipëri
The thermal water springs and wells in Albania

Lloji i burimit Springs	Vendndodhja Location	Tempe-ratura (°C)	Kripëra Salts (mg/l)	Prurja Yeild (l/sek
Burim natyror Natural springs	Peshkopi,Mamurras (Tiranë),Shupal (Tiranë), Llixha Elbasan, Tervoll (Gramsh), Langaricë (Permet), Sarandoporo (Leskovik), Krane (Sarande).	21-60	0.3-26	10-40
Puse të thellë Deep wells	Kozani, Ishëm, Galigat, Bubullimë, Ardenicë, Seman, Verbas.	29.3-65.5	1-19.3	0.9-18
			TOTAL	>130

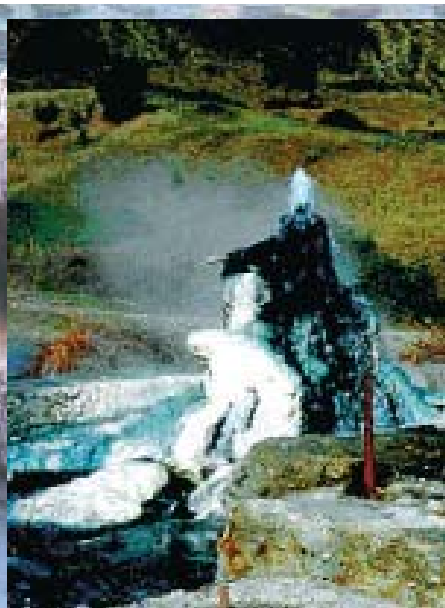
HARTA E ZONAVE DHE BURIMET E PUSET TERMALE

MAP OF THE THERMAL ZONES AND LOCATION OF THERMAL SPRINGS AND WELLS

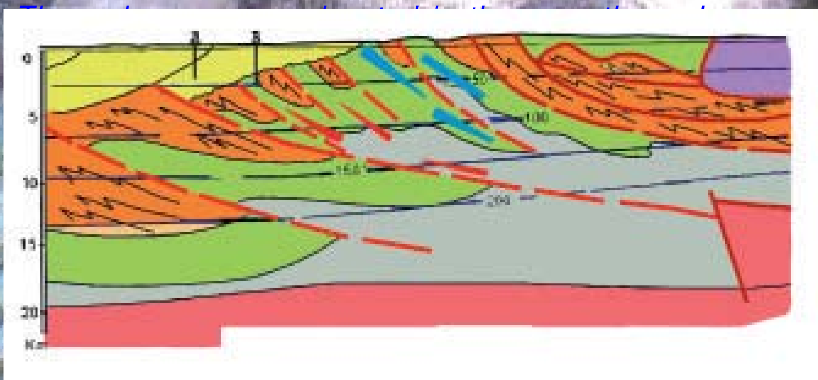


Këto burime të ujërave termalë ndodhen kryesisht afër thyerjeve tektonike krahinore dhe në brezat sizmikisht aktivë. Në përgjithësi, këto ujëra qarkullojnë nëpër shkëmbinjtë karbonatikë të strukturave të ndryshme dhe të nënshtratit me shkëmbinj kriporë, deri disa kilometra thellë. Ujërat termalë përmbajnë kripëra, gas të përthithur dhe lëndë organike. Ujërat janë të tipeve sulfate, sulfide, metane, jodure-bromi. Nga puset e thellë, uji termal vjen nga thellësitë (800-3000 m) nga rezervuarë karbonatikë ose ranorikë. Burimet dhe puset termale janë të vendosur kryesisht në tri zona gjeotermale:

These thermal water springs are mainly near zones of regional tectonic fractures, in seismic active belts. Generally the water circulates through carbonatic rocks of the structures and evaporitic beds in some kilometers of depth. The water of these springs contains salt, absorbed gas and organic matter. They are sulfide: methane, iodine-bromium and sulfate types.In many deep oil and gas wells there are thermal water fountain outputs. These waters comes from different depth levels (800-3000 m) of limestone and sandstone *reservoirs.*



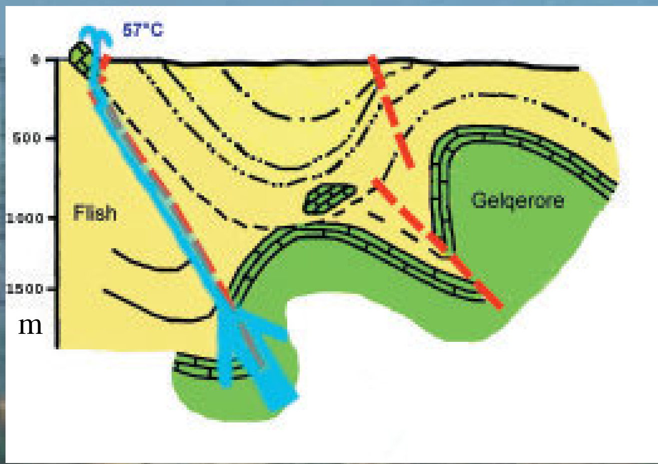
Pusi gjeotermal Kozani-8
Kozani-8 geothermal well



Profil gjeotermal krahinor Tiranë-Peshkopi. Zona gjeotermale e Krujës
Regional Geothermal Section Tirana- Peshkopi, Kruja Geothermal Zone

Zona gjeotermale e Krujës **është zona me resurset më të mëdha gjeotermale. Ajo ka një shtrirje të përgjithshme prej 180 kilometra dhe gjerësi 4-5 kilometra, si edhe ka resurse gjeotermale të identifikuara $5.9x10^8$-$5.1x10^9$ GJ. Kjo zonë fillon nga bregderi i Adriatikut në veriperëndim të Tiranës dhe vazhdon në juglindje në territorin grek. Ajo përfaqëson një varg strukturash antiklinale me bërthamë karbonatike të mbuluara nga flishi Paleogjenik dhe nga molasa të Tortonianit. Antiklinalet kanë gjatësi 20-30 kilometra. Ato janë asimetrike dhe krahët e tyre perëndimorë janë të këputur nga thyerjet tektonike.**

Kruja geothermal zone ***represents a zone with the biggest geothermal resources. Kruja zone has a length of 180 km. Identified resources***



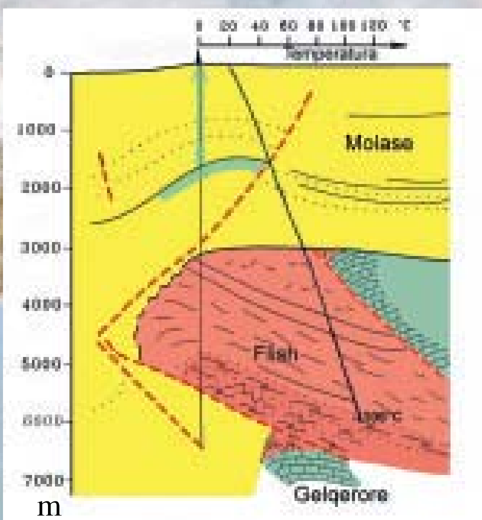
Profil gjeotermal, Zona Gjeotermale e Krujës

Geothermal Section, Kruja Geothermal zone

Pusi Gjeotermal Ishmi 1/b*Geothermal well Ishmi 1/b*

Zona gjeotermale e Ardenicës ndodhet në Ultësirën Bregdetare të Shqipërisë, në veri të Fierit. Aty shtrihen struktura e Ardenicës, e Semanit etj. Kjo zonë shtrihet në pjesën e Ultësirës Pranadriatike ku kalojnë thyerje krahinore tektonike. Uji del në sipërfaqen e Tokës nga thellësia nëpërmjet puseve, duke patur temperaturë rreth 32-38°C në sipërfaqe, dhe prurje 15-18 l/sek. Prerja gjeologjike e ujëmbajtësit në këto struktura përfaqësohen nga shtresa ranorësh masivë deri të imët, të veçuar nga shtresa argjilash dhe alevrolitesh. Trashësia e prerjes së ujëmbajtësit arrin disa qindra metra, duke u ndodhur midis thellësive 1-2 km. Shtresat ranore të ujëmbajtësit kanë trashësi nga disa metra deri në 20 metra.

Ardenica geothermal zone *is located in the coastal area of Albania, in sandstone reservoirs.*



Profil gjeotermal, Zona Gjeotermale e Ardenices

Geothermal Section, Ardenica Geothermal zone

Zona gjeotermale e Peshkopisë ndodhet rreth 2 km në juglindje të qytetit të Peshkopisë. Atje ndodhen disa burime të vendosur pranë njëritjetrit. Në këta burime, uji buron në shpatin e një lumi, që ndërtohet nga depozitime flishore. Burimet lidhen me një zonë të tektonikës shkëputëse të thellë, në periferi të diapirit gipsor. Prurja e disa burimeve arrin deri 14-17 l/sek. Temperatura e ujit arrin deri 43.5°C.

Peshkopia gjeotermal zone *at northeastern area of Albania. Several springs are located with disjunctive tectonics of the gypsum diapir.*

Deri tani vetëm disa nga ujërat e burimeve termale, si ato të Llixhave në Elbasan, në Bilaj të Fushë Krujës, në Peshkopi etj. shfrytëzohen vetëm për kurime të sëmundjeve të ndryshme. Ky shfrytëzim bëhet në mënyrë primitive, si koncept dhe si mundësi zhvillimi.

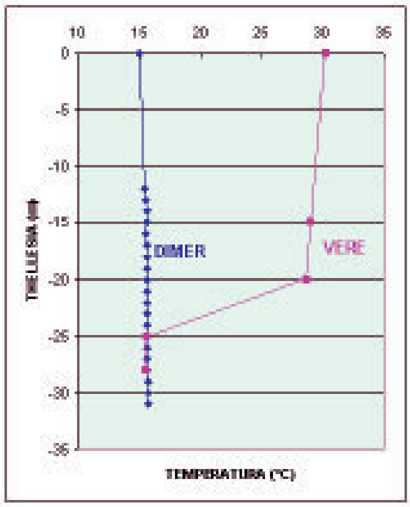
Until now the thermal waters of some springs and wells in Albania are used with primitive technology only for health purposes.

E NESËRMJA E SHFRYTËZIMIT TË ENERGJISË GJEOTERMALE NË SHQIPËRI

Shqipëria përfaqëson një vend me potencial të energjisë gjeotermale të entalpisë së ulët, që mund të shfrytëzohen për qëllime ekonomike. Përdorimi i energjisë gjeotermale duhet të bëhet me teknologji moderne, me skemë integrale të shfrytëzimit të energjisë gjeotermale: pompa të nxehtësisë dhe të energjisë diellore, si dhe të shfrytëzohet me mënyrë kaskadë, nga temperaturat e larta deri sa të ftohet.

Shfrytëzimi i ujërave termale të burimeve ose të puseve bëhet tërheqës nga fakti se ato përgjithësisht ndodhen në zona të zhvilluara nga ana urbane, me natyrë piktoreske dhe pranë qendrave historike.

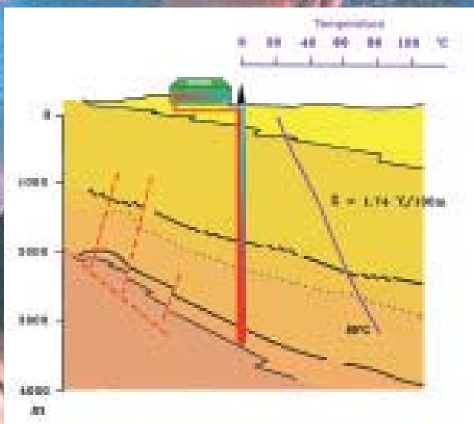
Situata gjeotermale në Shqipëri ofron tre drejtime të shfrytëzimit të energjisë gjeotermale, që aktualisht janë pothuajse të pa lëvruara:



Temperatura e shtresave pranësipërfaqësore, Tiranë

Së pari, përdorimi i sistemit Këmbyes Nxehtësie-Pus (KNP)-Pompë Termike (PT) për ngrohjen e banesave, duke shfytëzuar nxehtësinë e shtresave pranësipërfaqësore të Tokës. Një këmbyes koaksial ose në formë U-je i nxehtësisë instalohet në shpime 30-150 m të thellë. Lëngu që qarkullon nëpër këtë këmbyes nxjerr nxehtësinë nga shtresat e Tokës. Këmbyes të shumëfishtë instalohen për të ngrohur godina të mëdha ose për bllok godinash publike etj. .

Së dyti, **uji i nxehtë i burimeve dhe i puseve. Këto ujëra mund të përdoren në mënyrë kaskade, për hotele me pishina me ujë të ngrohtë për rekreacion dhe dëfrim të popullsisë duke zhvilluar turizmin, për klinika moderne për mjekimin e sëmundjeve të ndryshme, për ngrohjen e banesave dhe të serave për lule dhe perime, për ferma të rritjes së rasatëve të peshqëve , të algeve, si edhe për nxjerrjen e mikroelementëve dhe kripërave natyrore për pomada për mjekimin e sëmundjeve të lëkurës dhe kozmetikë.**



Burim vertikal nxehtësie

Së treti, përdorimi i puseve të thellë të naftës dhe gazit çift ose të vetmuar për të shfrytëzuar energjinë gjeotermike, si "Burime vertikale drejtvizore nxehtësie". Në 2000m thellësi temperatura arrin vlera 48 °C. Në puse të vetmuara mund të montohen sisteme të mbyllur qarkullues së ujit të ftohtë për tu ngrohur në thellësi. Uji i ngrohur nga nxehtësia e shkëmbit ngjitet lart dhe mund të përdoret për ngrohjen e serave etj. siç tregohet në figurë.

Shfrytëzimi i energjisë gjeotermale si energji alternative në Shqipëri duhet të fillojë sa më parë, me anën e projekteve të përshtatshme. Investimet për shfrytëzimin e energjisë gjeotermike janë investime të rëndësishme fitimprurëse.

FUTURE OF THE DIRECT USE OF GEOTHERMAL ENERGY IN ALBANIA

Geothermal situation of low enthalpy in Albania offers three directions for the exploitation of geothermal energy, which is unused until now. This exploitation must realized by integrated scheme of geothermal energy, heat pumps and solar energy, and cascade use of t his energy:

- Firstly, **space-heating system**, that uses ground heat in the shallow borehole "heat exchanger (BHE)-Heat Pumps system". These systems, actually are presented as the most popular and technologically advanced. Shallow, coaxial or U-shaped BHE's are installed in 30-150 m deep boreholes to extract heat from the ground by closed-fluid circulation . Multiple BHE's are installed for larger units like community buildings etc. In many European Community Countries have been presented great efforts to reduce its dependence from foreign fossil fuels (Rybach L.et al. 2000). Indigenous sources of energy like that heat content of the subsurface is especially i n focus, also due to environmental concern (do not generate any greenhouse effect caused by CO_2 emissions).
- Secondly, **thermal sources of low enthalpy** and with maximal temperature up to 80°C. These are natural sources or wells in a wide territory in Albania, from the south near Albanian-Greek boundary to northeast district in Diber Region.

Thermal waters of springs and wells in Albania may be used in several ways:

1. Hotels, with thermal pools, for development of echo-tourism, and modern SPA clinics for treatment of different diseases.

Such centers may attract a lot of clients not only from Albania. The waters have a good curative properties and springs are situated in nice places, near sea side, mountains or Ohrid Lake.

At the present, some private and public SPA, are located in geothermal springs and wells in Albania: **Lixha Elbasani SPA, Bilaj Balneological Center** (Ishmi 1/b well), **Peshkopia (Diber district) SPA, Sarandaporo (Leskovik Disrict) SPA, Langarica-Ura Kadiut (Permeti District) SPA.** The oldest and most important one is Elbasani Llixha SPA, is located about 10 km south of Elbasani city and 61 km in south-east of Tirana, in the Central part of Albania. By national road communication, Llixha area is connected with Elbasani and Tirana. These thermal springs have been used for about 2000 years. According to historical data there was a thermal center in Elbasani Llixha thermal springs, near of the old road "Via Egnatia" that linked Durresi and Constantinople. There are about 7800 people per year treated for their illness. Llixha Elbasani springs and Kozani-8 well have the possibilities for modern complex exploitation. The beautiful landscape of Elbasani area is not only for medical treatment centers but also as tourist place. This area is located near of the well know perarl , Ohrid Lake, and Gjinari mountaint , with their fantastic forests and nice climate. Ishmi 1/b geothermal well is located in the beautiful Tirana field, near of Mother Theresa (Tirana) Airport, near of Adriatic coastline and Kruja - Skendergeg Mountain.

Park Hotel- SPA- Llixha Elbasan

Llixha Elbasani thermal spring

3. The hot water can be used also for heating of hotels, SPA and tourist centers, as well as for the preparation of sanitary hot water used there. Near these medical and tourist centers it is possible to built the greenhouses for flowers and vegetables, and aquaculture installations.
4. From thermal mineral waters it is possible to extract useful chemical microelements as iodine, bromine, chlorine etc. and other natural salts, so necessary for the preparation of creams for the treatment of many skin diseases and as beauty care products. From these waters it is possible to extract sulphidric and carbonic gas. It is possible to built installations for processing of mineral waters.

Consequently, the sources of low enthalpy geothermal energy in Albania, which are at the same time the sources of multi-element mineral waters, they represent the basis for a successful use of modern technologies for a *complex and cascade exploitation* of this energy, achieving an economica l effectiveness. Such developments are also useful to open new working places and improv the life level for local communities living near thermal sources.

- **Thirdly, the use of deep doublet abandoned oil and gas wells and single wells for geothermal energy exploitation, in the form of a "Vertical Earth Heat Probe".** The geothermal gradient of the Albanian Sedimentary Basin has average values of about 18.7 mK·m^{-1}. At 2 000 m depth the temperature reaches a value of about 48°C . Near of these wells, greenhouses can be build .

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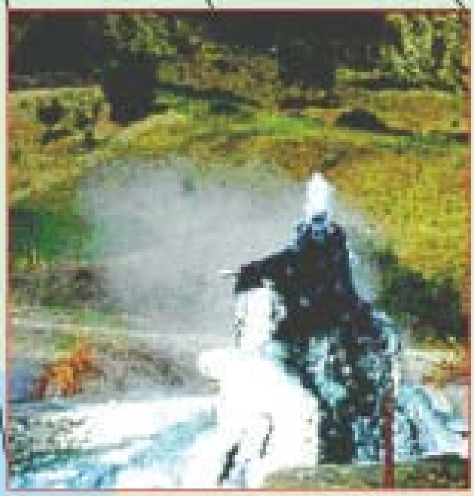
Temperatura	65.5°C
Prurja	10.3 l/s
Kapaciteti	1.93 MWt
Rezerva specifike	39.6 GJ/m2
Fuqia e instaluar	2070 kW



ZONA GJEOTERMALE KOZAN

Energjia e humbur për rendiment 0.6 është 253 Milion kWh ~ 20 Milion USD

NJEREZ !
Mos e hidhni këtë pasuri në lumë

Autorë:
Prof. Dr. A. Frashëri, Prof. Dr. N. Frashëri, Prof. Dr. N. Pano, Prof. Dr. S. Bushati
Instituti i Informatikës dhe i Matematikës së Aplikuar kontribuoj për përgatitjen e broshurës

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DIRECTIONS OF INTEGRATED AND CASCADE DIRECT USE OF GEOTHERMAL ENERGY IN ALBANIA

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Abstract

Large numbers of geothermal energy of high and low enthalpy resources, a lot of mineral water sources represent the base for successfully application of modern technologies in Albania, to achieve economic effectively. There are many thermal springs and wells. Their water has temperatures that reach values of up to 65.5°C.

In the paper are presented the temperatures maps at deferent depth, geothermal map, heat flow density map, geothermal zones map and geothermal energy resources map etc.

At present, the thermal waters of some springs and wells are used only for health purposes.

1. Introduction

The geothermal situation of low enthalpy in Albania offers three directions for the exploitation of geothermal energy. Direct use of the environmental friendly geothermal energy must be realized by integrated scheme of geothermal energy-heat pumps and solar energy, and cascade use of this energy:

- **Firstly**, thermal sources of low enthalpy and of maximal temperature up to 65.5°C.

Thermal waters of springs and wells may be used in several ways:

1. Modern SPA clinics for treatment of different diseases and hotels, with thermal pools, for development of eco-tourism. Such centres may attract a lot of clients not only from Albania, because the good curative properties of waters and springs are situated at nice places.
2. Near these thermal springs it is possible to built the greenhouses for flowers and vegetables, aquaculture and agriculture products drying installations.
3. The hot water can be used also for heating of hotels, SPA and tourist centers, as well as for the preparation of sanitary hot water used there.
4. From thermal mineral waters it is possible to extract very useful chemical microelements and other natural salts. From these waters it is possible to extract sulphidric and carbonic gas.
5. There are some low temperature mineral waters spring, example in Langarica and Sarandaporo springs near of Albanian-Greece border, where is possible to build installations for mineral potable water.

- **Secondly**, greenhouses heating and aquaculture installations, by use of the vertical heat exchangers in the deep oil and gas abandoned well in the complex with heat pumps and solar energy systems.

- **Thirdly**, the Earth Heat can be use for space heating and cooling, and greenhouses heating by modern systems Borehole Heat Exchanger-Geothermal Heat Pumps.

Energjia gjeotermale e shtresave në thellësi të Tokës si edhe uji i nxehtë që përmbajnë rezervuarët gjeotermale sot përdoren gjithënjë e më tepër edhe për ngrohjen e serave për prodhimin e perimeve dhe të luleve. Janë të famshme serat në Lardarelo të Italisë, ku prodhohen lule ekzotike dhome. Sipërfaqet e serave të ngrohura me energjinë gjeotermale është një investim me përfitime të mëdha, prandaj ato po shtohen nga viti në vit në vende të ndryshme të botës. Në shtetet për rreth Shqipërisë, aktualisht funksionojnë shumë sera, me sipërfaqe si më poshtë vijon: Macedonia 62.4 ha, Greece 34 ha, Bulgary 22 ha, Geothermal Energy use for greenhouses in Hungary is 206.7 MW. Në Itali, vlen të përmëndet si shembull pozitiv se vitet e fundit, ne veri të Romës, janë ndërtuar një seri serash demostrative moderne me sipërfaqe (8 x 30 x 3.70) m dhe (24 x 20 x 3.40) m, të cilat ngrohen me energjinë e ujit gjeotermal me temperaturë 40^{o}C dhe prurje 10 l/sek. (Koreneos C.J. etj. 1999, Bojadgieva K. etj. 1999, Campioti C. etj. 1999, Kralj P. 1999, Arpasi M. etj. 1999, Popovska S etj. 1999):

2. Geothermal Regime in Peri Adriatic Depression and Ionian zone

The Geothermal Regime of the Albanides is conditioned by tectonics of the region, lithology of geological section, local thermal properties of the rocks and geological location.

2.1. Temperature

The temperature at 100 meters depth vary from less than 10 to almost 20°C. Highest temperature values at 100 m characterize the Adriatic coastline and the southern part of the country. The characteristic temperatures at 500 meters depth rise from 21 - 20°C. The highest temperatures, up to 36 °C, have been measured at 1000 meters depths in Peri-Adriatic Depression wells. The temperature is 105.8°C at 6000 meters depth, in the central part of the Peri-Adriatic Depression. The isotherm runs parallel the Albanides strike. The configuration of the isotherm doesn't change down to a depth of 6000m. Going deeper and deeper the zones of highest temperature move from southeast to northwest, towards the center of the Peri-Adriatic Depression and even further towards the northwestern coast. The described geothermal field, with relatively low values of temperature, is a characteristic of the sedimentary basins with a great thickness of sediments.

2.2. Geothermal Gradient

In the External Albanides the geothermal gradient is relatively higher. The geothermal gradient displays the highest value of about 21.3 mK.m^{-1} in the Pliocene clay section in the center of Peri-Adriatic Depression. The largest gradients are detected in the anticline molasses structures of the center of Pre-Adriatic Depression. The gradient decreases about 10-29% where the core of anticlines in Ionic zone contains limestone. Elsewhere in Ionian zone, the gradient is mostly 15 mK.m^{-1}. The modeling results show that deeper than 20 km is observed decreasing of the gradient. This change of the gradient is coincided with the top of the crystal basement.

In the Albanian Sedimentary Basin, geothermal gradient changes from one formation to the others. The geothermal gradient greatest values were observed in the clay sections. Whereas decreases of geothermal gradient are observed with increasing of sand content at geological section.

Local variations of the temperature and their geothermal gradient values are observed on a distances of 7-8 km. For example, at a depth of 3000m on these distances the temperature may vary from 8-9°C. The geothermal gradient values changes from 10.5 to 17.5 $mK.m^{-1}$, even in vertical direction,

There occur deviations from the normal trend of the above-mentioned phenomenon in case of lateral influences**.**

Over-pressure in the molasses of the Albanian Sedimentary Basin has a great influence on the values of geothermal gradient (Liço R. et al. 1998).

2.3. Heat Flow Density:

Regional pattern of heat flow density in Albanian territory is presented in the Heat Flow Map. There are observed two particularities of the scattering of the thermal field in Albanides:

Firstly, maximal value of the heat flow is equal to 42 mW/m^2 in the center of Peri-Adriatic Depression of External Albanides. The 30 mW/m^{-2} value isotherm is open towards the Adriatic Sea Shelf. Heat flow density values are lower than 25-30 mWm^{-2} in Albanian Alps area. This phenomenon has taken place owing to the great thickness of sedimentary crust, mainly carbonatic one in this zone.

Secondly, in the ophiolitic belt at eastern part of Albania, the heat flow density values are up to 60 mW/m^2.

2.4. Water Resources of Geothermal Energy

Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters with a temperature that reach values of up to 65.5°C are sulphate, sulphide, methane, and iodinate-bromide types (Tab. 1, Tab. 2).

THE THERMAL WATER SPRINGS IN ALBANIA

Tab. 1

No. spring	Spring and region	Temp °C	Geographic coordinates		Yeild l/sek
			Latitude N	LE	
1	Mamurras 1 & 2	21-22	41°31'3"	19°38'1	11.7
2	Shupal, Tirana	29.5	41°26'9"	19°52'2	<10
3-a	Llixha Elbasan	60	41°01'9	20°05'	15
3-b	Hydrat, Elbasan	55	41°1’3	20°°5’15	18
4	Peshkopi	43.5	41°41'2	20°24'	14
5	Ura e Katiut Langaricë, Permet	30	40°14'4	20°22	>160
6	Vromoneri, Sarandoporo, Leskovik	26.7	40°5'6	20°37'3	>10
7	Finiq, Sarande	34	39°52'9	20°03'	<10
8	Përroi i Holtes, Gramsh	24	40°55'5	20°09'4	>10

9	Postenan, Leskovik	Burim avulli	40°10’4	20°33’6	
10	Kapaj, Mallakastër	16.9-17.9	40°32’5	19°19’3	12
11	Selenicë, Vlorë	35.3	40°32’5	19°35’5	<10

In many deep oil and gas wells there are thermal water fountain outputs with a temperature that varies from 32 to 65.5°C (table 2, Plate 17)

THERMAL WELLS IN ALBANIA

Tab. 2

No.	Well	Temp. in °C	Geographical Coordinates		Yeild l/sek
			Latitude N.	Longitude E.	
1	Kozani 8	65.5	41°06'	20°01'1	10.3
2	Ishmi 1/b	60	41°34'	19°41'	3.5
3	Galigati 2	45-50	40°57'1	20°09'4	0.9
4	Letan	50			5.5
5	Bubullima 5	48-50	41°19'3	19°40'6	<10
6	Ardenica 3	38	40°48'8	19°35'6	15-18
7	Semani 1	35	40°50'	19°26	5
8	Semani 3	67	40° 49’,8	19°25’	30
9	Ardenica 12	32	40°48'7	'19°35'7	<10
10	Verbasi 2	29.3			1-3

Until now only thermal waters of the springs 1, 2, 4, and 6 and wells 1, 2, 3 in Albania are used only for health purposes by old technologies of the SPA.

Albanian geothermal areas have different geologic and termo-hydrogeologic features. Geothermal areas are linked with disjunctive tectonics and seismological active belts.

2.5. Geothermal Zones

Thermal sources are located in three geothermal zones:

Kruja geothermal zone, represents a zone with bigness geothermal resources. Kruja zone has a length of 180 km. Kruja Geothermal Zone is extended from Adriatic Sea at North and continues in South-Easter area of Albania and in Konitza area in Greece [Frashëri A. et al. 2003, Fytikas M.D. and Taktikos S. 1993]. Geothermal aquifer is represented by a karstified neritic carbonatic formation with numerous fissures and micro fissures, with an. effective porosity is less than 1% and the permeability ranges from 0.05-3.5 mD. The hydraulic conductivity of the limestone section varies between $8.6 \times 10_{-10}$ – 8.8×10^{-8} m/s and the transmissivity ranges from 8.6×10^{-7} – 8.5×10^{-5} m2/s.

Surface water temperatures in the Tirana-Elbasani zone vary from 60° to 65.5°. In the aquifer top in the well trunk of Kozani - 8 temperature is 80°C. Hot water has a salinity of 4.6-19.3 g/l. Elbasani Llixha water contains Ca, Na, Cl, SO_4, and H_2S [Avgustinsky et al., 1957] while in the Tirana-Elbasani, thermal waters are of Mg-Cl type. They contain the cations Ca, Mg, Na and K, as well as the anions Cl, SO_4, and HCO_3 with pH to 6.7-8 and density of 1.001-1.006 g/cm^3.

. Elbasani Nosi Llixha water has the following formula [Avgustinsky V.L. 1957]:

$$H_2S_{0.403}M_{7.1}\frac{Cl_{59}SO^4_{38}}{Na_{46}Ca_{35}}$$

The Langarica river thermal springs, near of the very beautiful Vjosa River valley, Postenani steam springs (Plate 24-a) and the Sarandaporo springs (Plate 24-c) can be found in the S of the Kruja geothermal area. Thermal water flows out from the contact between Eocene fissured and karstified limestone and the flysch section. The steam flows from tectonic fault.

At both Langarica River shores, are located thermal Bënja thermal springs, well know from the Romanian period. These waters are much different. They do not contain H_2S, CO_2 and are a factor of 7-9 times less mineralized than waters from the Tirana-Elbasani zone. Mineral water of these springs is drinkable. Water temperature is 29 ^oC. Yield is 30-40 liters/sec.

Near of Albanian-Greek border is located Sarandaporos thermal and mineral drinkable water springs. The temperature is 27.6 ^oC. Yield more 40 liters/sec. Geothermal springs at Kavasila in Greece are located in southern Sarandaporo riverside. Kavasila thermal springs and Sarandaporo in Albanian side are springs are presented the single geothermal system, which at northern direction is continued with steam springs in Postenan Mountain in Leskovik and Bënja geothermal springs in Përmeti.

Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs. The Ardenica geothermal area is situated 40 km N of Vlora within the Peri-Adriatic Depression. It comprises several molasses Neogene brachyanticlines The Ardenica geothermal area is intercepted by the Vlora-Elbasan-Dibra transversal fault. The Ardenica geothermal reservoir comprises sandstone sections of Serravalian, Tortonian and Pliocene age. These sandstone layers are composed of coarse, medium and fine grains. Effective porosity of the aquifers is about 15.5 % and the permeability reaches 283 mD. Hydraulic conductivity is 4.98 m/s and transmissivity has a value 8.9 x 10^{-5} m^2/s. These reservoir properties translate into an output of 5-18 l/s.

Ardenica thermal water is Ca-Cl type, with 21.2 mg/l iodine, 110 mg/l bromide and 71 mg/l boric acid, and has a formula:

$$M_{58.8}\frac{Cl_{98}}{Na_{86}}$$

Peshkopia geothermal zone is located in the Northeast of Albania. At distance of two kilometers east of Peshkopia, water at 43.5^{o}C flows out of a group of thermal springs on a river slope composed of flysch deposits. Some of the springs yield flow rates up to 14 l/s. Water temperature is 43.5 °C. The occurrence of these springs is associated with a deep fault at the periphery of a gypsum diapir of Triassic age that has penetrated Eocene flysch, which surround it like a ring.

The thermal waters are of sulphate-calcium type, with a mineralization of up to 4.4 g/l, containing 50 mg/l H_2S. Their chemical formula is [Avgustinsky V. L. 1957]:

$$H_2S_{0.0495}M_{4.4}\frac{SO^4_{56}}{Ca_{65}}$$

2.6. Geothermal Resources

Kruja Zone, concentrates most geothermal resources in Albania. The most important resources, explored until now, are located in the Northern half of Kruja Geothermal Area, from Llixha-Elbasan in the South to Ishmi, in the North of Tirana. For the Tirana-Elbasani subzone heat in place (H_o) is 5.87 x 10^{18} – 50.8 x 10^{18} J, identified resources (H_i) are 0.59 x 10^{18} – 5.08 x 10^{18} J, while the specific reserves ranges between values of 38.5-39.6 GJ/m^2.

The second subzone, Galigati, has lower concentration of resources 20.63 GJ/m^2, while geothermal resources amount to 0.65 x 10^{18} J. These reserves have been extrapolated for this whole subzone up to the Albanian-Greek border.

Ardenica Zone. Ardenica reservoir has 0.82 x 10^{18} J. Resources density varies from 0.25-0.39 GJ/m^2. The boreholes have been abandoned and await renewed investment into geothermal exploration.

Peshkopia zone. Water temperature and big yield, stability, and also aquifer temperature of Peshkopia Geothermal Area similar are with those of Kruja Geothermal Area. For this reason geothermal resources of Peshkopia Area have been estimated to be similar to those of Tirana-Elbasani area.

3. Direct use of geothermal energy for greenhouses heating in Albania.

Energjia gjeotermale për ngrohjen e serave përftohet në dy rrugë:

1. Nga ujërat gjeotermalë që fontanojnë nga burime dhe puse të thellë
2. Duke përdorur sisteme moderne **Këmbyes Nxehtësie Vertikale** në puse të thellë, duke i kthyer ato në ***Burime Vertikale Nxehtësie*** (Clauser Ch. 1997, Chuanshan D etj. 1995, Lund J.W. 1996).

a) Puset e thellë qa japin ujë të nxehtë, energjinë diellore ose të erës.

Midis puseve të braktisur të naftës dhe të gazit, siç u tregua në paragrafin 2-4, ka nga ata që kanë fontanuar ujë termal, me temperatura dhe debite të ndryshme. Uji i nxehtë i këtyre puseve mund të shërbejë për ngrohjen e serave. Veç puseve që tregohen në paqyrën e mësipërme, mund të gjenden edhe puse të tjerë në kushte analoge që të përvehtësohen për ujë termal.

Por, nga puset e treguar në këtë tabelë ka që tashmë janë likuiduar, si pusi Semani3, i cili ndodhet në det. Ka të tjerë si Ardenica-12 që është mbushur me hekurishta.

Prandaj rekomandojmë se është me shumë vlerë të ndërmerret një studim që të ketë për objektiva:

- Evidentimi i të gjithë puseve që kanë fontanuar ujë të nxehtë, si edhe parametrat hidrogjeologjike e hidrokimikë të tyre.
- Vlerësimi i gjendjes teknike të tyre dhe i mundësive teknike konkrete për vënien e tyre në shfrytëzim.
- Prognoza për gjetjen e puseve të tjerë të braktisur që mund të përvehtësohen për ujë të nxehtë, në afërsi të puseve që tashmë njihen si gjeotermalë, ose në kushte gjeologo-strukturore analoge.
- Studimi i kushteve hidrogjeologjike dhe teknike të puseve gjeotermalë të rinj të mundshëm, nga fondi i puseve të braktisur.

b) Puset e thellë të braktisur të naftës e gazit, si burime vertikale nxehtësie, dhe energjinë diellore.

Nje burim tjeter i energjise termike eshte shfrytezimi i puseve te naftes dhe te gazit te abandonuar, te cilet ndodhen ne zonat me gradient gjeotermik te larte, ose janë të thellë dhe kanë temperaturë të lartë në fund të tyre. Ato sherbejne si **"Burim drejtvizor vertikal te nxehtesise"**. Në kapitullin 6 do të paraqitën rezultatet e modelimit për mundësinë e përdorimit të puseve që ndodhen në Ultësirën Parandriatike dhe në zonën Jonike si Burim drejtvizor vertikal nxehtësie.

Nxehtësia e shtresave të thella të Tokës mund të nxirret me anën e këmbyesve vertikalë të nxehtësisë që vendosen në trungun e pusit. Këto këmbyes mund te jenë në formën e U-së ose koaksialë (fig.2). Efektiviteti i këtyre burimeve vertikale të nxehtësisë përcaktohet nga shumë faktore:

- Thellësia e pusit,
- Gradienti gjeotermal,
- Vetitë termofizike të shkëmbinjve që ka përshkuar pusi,
- Konstruksioni i këmbyesit të nxehtësisë që futet në pus,
- Regjimi i qarkullimit të ujit në sistemin pus-këmbyes vertikal nxehtësie.
- Cilësia e izolimit termik midis tubingut dhe hapësirës unazore si edhe,
- Efektet e kapacitetit të këmbyesit vertikal të nxehtësisë. Optimizimi i instalimit (tuba termikisht të izoluara por të shtrenjtë dhe tuba plastikë të lirë por me efektivitet më të ulët) duhet të merret në konsideratë lidhur me kërkesat për nxehtësi (temperaturë dhe kapacitet).

Mbështetur në të dhënat gjeotermale për puse në Ultësirën Pranadriatike, Dr.Johaim Popey, në Geothermie Neubranderburg GmbH, Gjermani, me kërkesën tonë bëri modelimin mathematikor e një "Burimi Vertikal Nxehtësie", dukë përcaktuar temperaturën dhe kapacitetin te ujit në grykën e pusit, pas gjysëm viti qarkullim të pandërprerë. Në modelim janë ndryshuar debiti i ujit, temperatura e ujit që injektohet në pus dhe standardi i izolacionit të tubove. Debitet e vogla janë çiftuar me temperatura më të larta në grykën e pusit, por me kapacitet më të vogël. Gradienti gjeëotermal është marrë 0.018 K/m.

Në tabelën e mëposhtme jepen rezultatet e modelimit mathematikor:

Debiti i ujit M^3/orë	Temperatura e ujit që injektohet ^oC	Standardi i izolacionit termik	Temperatura e ujit të ngrohtë në grykë të pusit ^oC	Kapaciteti termik, Në kW
2	10	Tub plastik	22	27
	0		17	40
10	10		25	174
	0		20	225
2	10	Ajër	40	69
	0		38	88
10	10		29	215
	0		24	275
2	10	Vakum	56	106
	0		56	128
10	10		30	235
	0		26	297

Në fig. 10 paraqiten grafikët e temperaturës për dy tipe izolacioni: tub plastik i perforcuar me izolacion xhami dhe për tub me izolacion me vakum të thellë. Tubingu 2” 7/8, debiti 2 m^3/h, temperatura e ujit që injektohet 10°C, gradienti gjeotermal 0.018 K/m.

Nga këto të dhëna të modelimit rezulton se në impiant duhet vendosur pompë nxehtësie që tubot plastike më të lirë të kenë eficencë të mjaftueshme për furnizim nxehtësie.

Për të patur temperatuyrë të lartë të ujit që del nga pusi, duhet të realizohet qarkullim i pandërprerë gjithëvjetor i ujit në këmbyesit e nxehtësisë të vendosur pus. Gjatë verës, kur temperaturat janë të larta, uji i nxehtë mund të përdoret nëpërmjet pompës së nxehtësisë për freskimin e serës. Uji termik i tepërt mund të përdoret për tharjen e frutave dhe perimeve. Ky drejtim i fundit sot gjen përdorim me efektivitet në shumë vende.

4. Vlerësimi energjisë termike për ngrohjen e serës.

Për shfrytëzimin optimal të energjisë gjeotermale për ngrohjen dhe freskimin e serës po parashtrojmë kushtet e zbatimit për sera industriale me xham, tip 3.20 x 2.86 (3.00)). Këto sera shërbejnë për kultivim perimesh si domate, kastraveca, speca etj dhe lule. Karakteristikat biologjike më të përgjithëshme të këtyre bimëve janë:

1. Temperaturat nën 0°C janë letale dhe si të tilla eskludohen në punën e serës.
2. Temperatura e stresit është nën +7°C.
3. Temperatura 10°C është temperatura minimale që duhet të jetë në serë.
4. Temperaturat optimale për natën janë +10°C deri +14°C.
5. Temperatura optomale për ditën janë +18°C deri +28°C.
6. Mbi +30°C deri +33°C fillon stresi ditor dhe cdekja e bimës.

Temperatura e ujit që disponohet nga një burim vertikal nxehtësie ne një pus, siç u tregua në paragrafin 6.1. është 30°C dhe debiti Q = 3 l/sek.

Është parashikuar që sera demostrative që projektohet të ndërtohet ka një sipërfaqe S = 0. 5 ha = 5 000 m^2.

Nga të dhënat hidrometeorologjike të paraqitura në kapitullin 5, për koeficient sigurie 10% , temperatura minimale në zonën e Fierit është t_{min} = - 8.6°C.

Sera ka dy humbje kryesore të energjisë termale:

1. ***Humbja për diferencën e temperaturave jashtë (t_j) dhe minimale e lejuar brënda (t_b) serës H_u:***

$$H_u = (t_b - t_j) \times K \times S_p$$

Për rastin e rajonit të Fierit, diferenca e temperaturave $\Delta t = t_b - t_j = 10^o - (-8.6^o) = 8.6^o C.$

ku: K është koeficient mesatar i përçueshmërisë termike, që për rastin e dhënë u pranua 4 k.kal/(m^2.orë.°C).

S_p – sipërfaqja e përgjithëshme e serës, që për rastin e dhënë është:

$$5\,000 \text{ m}^2 + 300 \text{ x } 2.4 = 5\,720 \text{ m}^2$$

(300 m është primetri i serës dhe 2.4 lartësia mesatare e saj).

Prandaj:

$$H_u = 18.6 \times 4 \times 5720 = 425568 \quad \text{kKal/orë}$$

2. ***Humbja për ajrim të serës (ventilim):***

$$H_{aj} = 1.5 \times V \times \Delta t$$

ku: V- vëllimi i serës, në m^3, që për erastin e dhënë është V = 500 x 2.4 = 12 000 m^3

Koeficienti 1.5 rezulton nga produkti i nxehtësisë specifike të ajrit (0.3 kKal/m^3) me numrin e ajrimeve në orë, që arrin në 5.

Prandaj:

$$H_{aj} = 1.5 \times 12000 \times 18.6^0 = 334800 \text{ kKal/orë}$$

Kësisoj, humba e përgjithëshme do të jetë”

$$H_{per} = H_u + H_{aj} = 760368 \text{ kKal/orë}$$

Energjia që përfitohet nga uji termale:

Energjia që përftohet gjatë një ore pompim i ujit termal në serë, me kusht që të ruhet $t_{min}=10^oC$ në brendësi të serës do të jetë:

$$E_u = \left(t_{uj}^o - t_{\min}^o\right) \times Q \text{, në kKal/sek}$$

ku: t_{uj}^o - temperatura e ujit termal

$t_{\min}^o$ - temperatura minimale që duhet të ruhet në serë

Q – debiti i ujit gjeotermal, në l/sek

Për një orë E = E_u x 3600”

Prandaj:

$$E = (30^o C - 10^o C) \times 3 \times 360 = 216000 \text{ kKal/orë}$$

Krahasimi i energjive:

Duke krahasuar energjinë e humbur (H_{pergj}) në serë me energjinë E të përftuar nga pompimi i ujit termal rezulton:

$$\Delta E = H_{pergj} - E = 760388 - 216000 = 544388 \text{ kKal/orë}$$

Siç duket, uji gjeotermal i dhënë nga pusi, nëpërmjet burimit vertikal të nxehtësisë (Këmbyesit Vertikal të Nxehtësisë) nuk ka sasinë e nevojshme të energjisë për të ngrohur serë. Në këto kushte, për të realizuar ngrohjen e nevojshme të serës, parashikohen disa variante:

a) Rritja e temperaturës së ujit termal:

Duke shfrytëzur barazimin:

$$E = H_{përgj} \text{ ose } E - H_{përgj} = 0$$

dhe duke paraqitur që për temperaturën e rritur e ujit t_{ujit1} mund të shkruhet

$$t_{ujit1} = t_u + \Delta t$$

ku: Δt- madhësia e rritjes së temperaturës

dhe rezulton:

$$[(30^oC + \Delta t) - 10] \text{ x } 3 \text{ x } 3600 = 760\ 388 \text{ kKal/orë}$$

pra $\Delta t = 50.4^oC$ dhe temperatura e ujit duhet të jetë:

$$t_{ujit1} = t_u + \Delta t = 30^oC + 50.4^oC = 80.4^oC$$

b) Rritja e debitit të ujit termal:

Nëse debiti i ujit termal do të jetë 11 l/sek me temperaturë 30^oC, energjia e përfituar në orë do të jetë:

$$E_u = \left(t_{uj}^o - t_{\min}^o\right) \times Q = (30 - 10) \text{ x } 11 \text{ x } 3600 = 792\ 000 \text{ kKal/orë.}$$

Energji e mjafuteshme për serën me sipërfaqe 0.5 ha.

Vlerësimi i temperaturës minimale në serë të kompensuar nga temperatura vetiake e ujit:

Nëse për serën do të përdoret vetëm uji me debit 3 l/sek dhe temperaturë 30^oC, rezulton që temperatura që humbet sera do të përcaktohet si më poshtë vijon:

$$H_{pergj} = H_u + H_{aj} = \Delta t \times 4 \times 5720 + \Delta t \times 1.5 \times 120000 =$$

$$= \Delta t \times (4 \times 5720 + 1.5 \times 12000)$$

duke pozuar $\Delta t = 10^oC - t_j$
do të rezultojë:

$$H_{per} = 216000$$

Ose $(10 – t_j)$ (4 x 5720 + 1.5 x 12000) = 216000
Dhe që këtej

$$T_j = + 4.72^oC$$

Llogaritja e energjisë suplementare të nevojshme:

Për ruajtjen e regjimit biologjik të nevojshëm në serë, për temperaturë të jashtme nën + 4.72^{o}C, mbështetur në të dhënat hidrometeorologjike të dhëna në tabelën 2 të kapitullit 5 mbi kushtet klimatike të rrethit të Fierit, duket se (fig. 11):

1) Temperatura –9.9^{o}C deri –5^{o}C (mesatarisht –7.45^{o}C) ndodhin vetëm për 0.1 ditë ose 2.4 orë.
2) Temperatura –4.9^{o}C deri0^{o}C (mesatarisht –2.45^{o}C) ndodhin vetëm për 0.8 ditë ose 19.2 orë.
3) Temperatura 0^{o}C deri 5^{o}C (mesatarisht +3^{o}C) ndodhin vetëm për 14.8 ditë ose 355.2 orë.

dhe për secilin rast llogarisit energjinë e humbur:

1) [4.72 – (-7.45)] x 40880 x 2.4 orë = 1 194 023
2) [4.72 – (-2.45)] x 40880 x 19.2 orë = 5 627 704
3) [4.72 – 3] x 40880 x 355.2 orë = 2 497 5391

Gjithesej 31 797 118 kkal në 15.7 ditë në vit ose 376.8 orë në vit

Nëse do të përdoret mazut për ngrohje, me fuqi 10 000 kKal/kg, për të përballuar kërkesat për energji suplementare gjatë këtyre 376.8 orëve në vit me temperatura më të ulta se minimalja e kërkuar e serës do të nevojiteshin:

3200 kg: 0.8 = 4000 litra

sasi kjo shumë e vogël e karburantit të nevojshëm gjate vitit.

5. Teknologjia e propozuar per ngrohjen e ujit për serën

Uji i serës do të ngrohet s me dy variante skemash:

a) Me skemë të kombinuar:

Kjo skemë përbëhet nga dy pjësë:

- Këmbyesi vertikal i nxehtësisë në pusin e thellë. Sipas modelimit ky pus do të japë 3 l/sek ujë me temperaturë 30^{o}C.
- Për të patur ujin me temperaturën e nevojshme 40^{o}C, në paralel me linjën e këmbyesit vertikal të nxehtësisë në pusin e thellë, do të vendoset një linjë me këmbyes vertikal të nxehtësisë në pus të cekët (100 m të thellë) me pompë gjeotermale nxehtësie, e cila do të japë 7 l/sek ujë me temperaturë më të lartë, që do të përzihet me ujin nga pusi i thellë, deri sa të arrihet temperatura e ujit 40^{o}C dhe me prurje 10 l/sek, aqë sa kërkon procesi i ngrohjes së serës.

b) Me Pompë gjeotermale nxehtësie me burim termal ujin e shtresave të basenit pranë sipërfaqësor zhavorror të kuaternarit.

Nje nga rruget me efektive sot ne bote per zhvillimin e sektorit energjtik eshte shfrytezimi me efektivitet i te gjithe burimeve energjitike dhe ne vecanti shfrytezimi i burimeve te rinovueshme te energjise. Ne shfrytezimin e burimeve te energjise sic u theksua nje vemendje te madhe ka marre shfrytezimi i burimeve te rinovueshme te energjise te integruara keto me teknollogji shume te avancuara sic jane impiantet e nxehtesise.

Pompat e nxehtesise krijojne shume avantazhe sidomos per shfrytezimin e burimeve sekondare te energjsie sic jane ujrat e ndryshme te proceseve industriale me nje temperature me te madhe se temperatura e mjedisit dhe vecanerisht per shfrytezimin e burimeve energjitike me potencial te ulet temeperature. Eksperienca shqiptare e deritanishme ne shfrytezimin e impianteve te pompave te nxehtesise eshte ne keto drejtime:

- Ne vitin 1990-1993 ne Departamentin e Energjitikes, Universiteti Politeknik i Tiranes, u be e mundur ndertimi i nje impianti te integruar te shfrytezimit te energjise diellore me anen e pompes se nxehtesise. Uji pas ngrohej ne impiantin e panelit diellore deri ne temeraturen 27-55 ^{0}C (ne varesi te stines) per ti rritur temeraturen deri ne potencialin e kerkuar perdorej impianti i pompes se nxehtesise, e cila bente te mundur rritjen e temperatures deri ne nivelin prej 60-90 ^{0}C te kerkuar nga ana e konsumatorit.
- Me ndryshimet me medha ekonomike dhe shoqerore qe ndodhen ne periudhen e transzicionit, energjia elektrike si burim me komod, me pak i kushtueshem, meqenese shume burime te tjera nuk ndodheshin me tregun shqiptar dhe meqenese energjia elektrike filloj te mos paguhej nga disa konsumatore solli perdorimin e energjise elektrike per ngrohje ne permasa shume te gjera. Ky konsum i teperuar i energjise elektrike ne familje sidomos per ngrohje solli krizen energjetike qe ne po perjetojme sot.

Ne vitet 1998-2003 dhe ne vazhdim filloi penetrimi i impianteve te pompave te nxehtesise “ajer-ajer” per ngrohje dhe freskim, impiante te cilat ne gjuhen e thjeshte quhen kondicionere. Parimi baze i ketyre impianteve eshte se ata bejne te mundur shfrytezimin e nxehtesive dytesore me potencial te ulet qofte edhe dhe duke harxhuar pune ne kompresorin perkates te ketij impianti behet rritja e potencialit te temperatures mbi nivelin e kerkuar nga konsumatori.

Le te pershkruajme impiantin e pompes se nxehtesise qe mund te jete “ajer – ajer” sic eshte rasti i impianteve shtepiak dhe atyre “uje – uje”, i cili mendohet te perdoret per shfrytezimin e energjise gjeotermale. Nxehtesia me potencial te ulet temperature e ujit gjeotermal kalon ne nje kembyes nxehtesie “te emertuar avullues” ne te cilin behet e mundur kalimi i nxehtesise nga energjia gjeotermike tek trupi i punes freoni. Me tej freonit i rritet temperatura nepermjet kompresorit te pompes se nxehtesise deri ne nje nivel 7-10 ^{0}C mbi nivelin e kerkuar prej konsumatorit. Kjo ben te mundur qe nxehtesia nga freoni te kaloje tek uji (mbartesi i nxehtesise) qe do te beje te mundur ngrohjen e te gjithe mjediseve. Pasija e pompes se nxehtesise ne te cilen behet i mundur transmetimi i nxehtesise nga freoni tek uji quhet kondesator i pompes se nxehtesise. Pas kondesatorit freoni kalon tek ventili droselues ne te cilin behet i mundur renia e presioni dhe pas kalon ne avullues dhe pas kesaj cikli perseritet vazhdimisht.

Pompa gjeotermale do të furnizohet me 10 l/s ujë me temperaturë rreth 15-16 ^{o}C. Pusi do të shpohet me diameter 212 mm, në të do të vendoset elektropompë zhytëse me debit 10 l/s dhe ngritje të ujit 30 m. Sipas të dhënave hidrogjeologjike, thellësia e tavanit të shtresave zhavorrore në rajonin e Myzeqesë është rreth 30 m. Niveli statik i ujit është në 7 m. Pompa do te vendoset në thellësinë 15 m, rrëth 2 m mbi nivelin dinamik të ujit. Pusi do të ketë thellësi 50 m. Gjithë shtresa

e hapur e zhvorreve do të jetë paisur me filtrin. Kolona e rrethimit do të jetë metalike 6”. Uji i nxjerrë nga elektropompa, nëpërmjet linjës së dërgimit do të pompohet në impiantin e pompës gjeotermale të nxehtësisë.

Pas daljes së ujit nga pompa e nxehtësisë do të injektohet sërish në shtresë, nëpërmjet një pusi me diametër 125 mm, thellësi 40 m, me kolonë plastmasi rrethimi.

Ne vijim jepen llogaritjet per permasimin e pompes se nxehtesise sipas skemes se meposhtme.

Parametrat kryesore te seciles pike te ciklit te pompes se nxehtesise jane:

Pika 1 ne hyrje te kompresorit: i1=190.49 kJ/kg
Pika 2 ne dalje te kompresorit: i2=208.80 kJ/kg
Pika 3 ne dalje te kondesatorit: i3=84.94 kJ/kg
Pika 1 ne dalje te ventilit droselues: i4=84.94 kJ/kg

Nxehtesia qe merret ne avulluesin e pompes se nxehtesise:

$$Q_2 = (i_1 - i_4) \times m_{freonit} = 293.3 kW$$
$$m_{freonit} \times (i_1 - i_4) = (\Delta t_{ujit}) \times c_{ujit} \times m_{ujit} \Rightarrow m_{freonit} = 2.77 kg\ freon / sekond$$

Puna qe do te harxhohet ne kompresor:

$$L = \frac{(i_2 - i_1) \times m_{freonit}}{\eta_0^i \times \eta_{mek} \times \eta_{elek}} = 83.5 kW$$

Konkluzioni i kesaj analize eshte qe pompa e nxehtesise do te zgjidhet me nje fuqi elektromotorri 83.5 kW.

5.2. Teknologjia e Burimit drejtvizor vertikal të nxehtësisë në pus.

Burimi drejtvizor vertikal i nxehtësisë në pus do të ndërtohet me një këmbyes nxehtësie koaksial deri në thellësinë 3000 m. Në pus do të futet një kolonë e termoizoluar. Tubingu do të ketë diametër 2”7/8. Uji do të injektohet nga kezingu, nëpër hapësirën unazore midis kolonës së rrethimit të pusit dhe kolonës së termoizoluar të këmbyesit të nxehtësisë. Uji i nxehtë do të dalë nëpërmet tubingut të kolonës.

Qarkullimi i ujit në burimin drejtvizor vertikaldo të nxehtësisë do të bëhet me anën e një pompe centrifugalë zhytëse e tipit SP 8A-10, me debit 3 l/sek dhe prevalencë uji deri 30 m. Pompa do të vendoset në thellësinë 25 m. Fuqia e pompës është 1.5 kW.

.

6. Vlerësimi paraprak i efektivitetit ekonomik të shfrytëzimit të nxehtësisë së shtresave të thella dhe te cekta të tokës për ngrohjen e serave.

6.1.Vlerësimi paraprak i investimeve të nevojshme për ndërtimin e një sere demonstrative

Më poshtë paraqit analiza e zërave të punës dhe kosto për njësi të serës industriale ne xham, me permasa 3.20 x 3.00 = 9.60 m^2.

a) ***Punime ndërtimi:***

Per nje plinte, me përmasa 35 x 35 x 20 cm, me beton arme e markës 200, dhe me vëllim 0.024 m^3 , si edhe nje kolone beton arme qe vendoset tek ajo. Kolona beton arme ka përmasa 12 x 12 x 100 cm, me vëllim 0.014 m^3. Plinta dhe kolona kanë 2 kg hekur betoni 2 kg , me diametër 6-8 mm. Vellimi dhe kosto eshte si me poshtë vijon:

1. Gërmim dheu 1 m^3 x 552 leke = 552 lekë
2. Beton arme "M200", 0.04 m^3 x 13 100 leke = 524 lekë
3. Hekur betoni 2 kg x 65.2 leke = 130.4 lekë

Gjithesej 1 206.4 lekë

b) ***Furnizimi dhe vendosja e konstruksionit metalik te seres:***

10 kg/m^2 x 9.6 m^2 = 96 kg $\approx$ 100 kg

100 kg x 280 l/kg = 28 000 lekë

c) ***Furnizimi e vendosje xhami pa ngjyrë, me trashësi 4 mm***

Sipërfaqja e mbulesës dhe sipërfaqja anësore për serën 0.05 ha është 633.2 m^2. Siperfaqja e nje njesie te seres:

$$\frac{633.2}{500.0} \times 9.60 = 12.13 \ m^2$$

Ku: 500 m^2, siperfaqja e projektuar ne plan horizontal e seres.

Furnizimi dhe vendosja e xhamave 12.13m^2 x 900 leke/m^2 = 10 942 lekë

d) ***Sistemi i ngrohjes (radiatorët)***

1. Furnizimi dhe vendosja e 4 tubove çelik me diameter 50 mm, trashesi 2.2 mm, me peshe 2.97 kg/m dhe aksesoret:

   4 tubo x 3.00 m x 2.97 kg/m = 35.64 kg

   35.64 kg x 210 leke/kg = 7 484 leke

2. Rakorderi + termoizolime të veçanta, afërsisht 120 leke

   Gjithesej 7 604 lekë

e) Sistemi i ajrimit

Sipas të dhënave ekzistuese kosto rreth 1 000 lekë per njesi sere

f) ***Sistemi i ujitjes***

1. Furnizim dhe vendosje tuba P.V.C. + rakorderi

   afërsisht 3.00 m x 0.2 kg/ml x 10 leke = 60 lekë

2. 3 x sprucatorë me kosto 1 000 lekë

   Gjithësej 1 060 lekë

i) Paisje elektrike dhe të ndryshme rreth 1 000 lekë per njesi

Totali (a) + (b) + (c) + (d) + (e)+ (f) = 58 296 lekë

Plus shpenzime plotësuese dhe TVSH, gjithese 30% = 17 489 lekë

Totali = 75 785 lekë per njesi sere

75 785 l/njesi : 9.9 m^2 njesia = 7 655 l/m^2

Per kosto e ndertimit te seres demostrative me siperfaqe 0.05 ha do te jete

:

7 655 x 500 m^2 = 3 827 500 leke ose rreth 32 000 USD

6.2.Shpenzimet për paisjen e pusit dhe të linjës së pompës gjeotermale të nxehtësisë:

A) **E pusit të thellë**

- Pompa e qarkullimit të ujit 180 000 lekë.

- Kolona e këmbyesit vertikal të nxehtësisë. Deri tani, megjithë përpjekjet e bëra nuk kemi mundur të sigurojmë ofertë për blerjen e kolonave speciale të termoizoluara, me çmimet përkatëse. Ky mbetet problem që kërkon zgjidhje në të ardhmen.

B) **E pusit të cekët dhe pompes gjeotermale te nxehtesise**

Nr.	Objekti	Sasia	Çmimi për njësi, në lekë	Shuma, Në lekë
1	Shpimi i pusit të marrjes së ujit, me diametër 212 mm	50 ml	5 600 l/m	280 000
2	Kolona e rrethimit dhe filtri, tub plastmasi, me diametër të jashtëm 6”	50 ml	2 500 l/m	125 000
3	Montimi i kolonës së rrethimit	50 ml	560 l	28 000
4	Shpimi i pusit të injektimit, me diametër 125 mm	30 m	4 900 l/m	147 000
5	Kolona e rrethimit e pusit të injektimit, plastmas 4”1/2	30 ml	1 180 l/m	33 600
6	Montimi i kolonës së rrethimit	30 ml	118 L	3 360
7	Elektropompa zhytëse së bashku me impiantin elektrik	1 komplet	31 000 L	31 000
8	Linja e dërgimit të ujit nga pusi në mjedisin e pompës gjeotermale të nxehtësisë, tub plastmasi	20 ml	780 l/m	15 600
9	Linja e dërgimit të ujit nga pusi në mjedisin e pompës gjeotermale të nxehtësisë, tub plastmasi	10 ml	780 l/m	7 800
10	Montimi i linjave të dërgimit të ujit pus-pompë nxehtësie	30 ml	78 L	2 340
11	Pompa gjeotermale e nxehtesise	1 komplet	1 500 000	1 500 000
12	Shpenzime të paparashikuara, 5% të totalit te pusit			33 685
	GJITHESEJ			**2 207 385**

Kësisoj, kosto e përgjithëshme për ndërtimin komplet të serës me sipërfaqe 0.05 ha është:

- Ndërtimi i serës 3 827 500 leke
- Ndërtimi i sistemit ngrohës 2 207 385 leke

Gjithësej 6 034 885 leke 50 300 USD

6.3 Shpenzimet operative në serë

Shpenzimet e kryera në serë, sipas analizave financiare të detajuara (Rafferty K., Boyd T., 1997) përbëhen nga:

- Kosto e serës (përfshirë serën dhe paisjee e punës) 122 – 153 USD/m^2
- Kosto e ndërtimit 78 - 87 USD/m^2
- Vlera e tokës

Shpenzimet operative në serë, në raport me totalin e shpenzimeve, kanë këtë strukturë vjetore:

• Puna	40 – 50%	27.8 USD/m^2
• Bimët, furnizimi dhe materiale	16 – 25%	13.4
• Ngrohje, energji elektrike, ndriçim, ujë	6 – 16%	7.2
• Pagesa siguracioni dhe kreditimi	17 – 19%	11.8
• Të ndryshme	8 – 10%	5.2
	Total	**65.4** USD/m^2

Për kushtet e ndërtimit të serës në Shqipëri, siç u tregua në paragrafin 6.2, kosto e ndërtimit komplet të serës është **6 034 885** leke ose **50 300** USD

Për një periudhë 15 vjeçare vetështlyerje të këtyre shpenzimeve, kosto për çdo vit do të jetë **402 325** lekë/vit **3 353** USD/vit.

Në mungese aktuale të një kostoje analitike të hollësishme, po mbështetemi pwr vlerësimin analitik të fisibilitetit jemi mbështetur në të dhënat e disa fermave shqiptare që kanë sera.Sipas tyre, e shpenzimeve totale të serës me sipërfaqe 1 ha arrin **900 000** lekë/vit**,** dhe për serën që projektohet me sipërfaqe 0.05 ha, këto shpenzime arrijnë **45000** lekë/vit**.**

6.3. Studim fisibiliteti i serës me ngrohje me ujë termal.

Për të realizuar këtë vlerësim kemi patur parasysh këta faktorë:

1. Shpenzimet në serë:

- Ndërtimi 402 325 lekë/vit
- Shpenzime operative totale 45 000 lekë/vit
- Shpenzime për energji elektrike të domosdoshme:
  - Puna e sistemit të pompës gjeotermale të nxehtësisë:
    83.5 kWh x 376.8 orë x 9 lekë = 282 564 lekë
  - Pompa e qarkullimit të ujit:
    4.2 kWh x 376.8 x 9 lekë = 14 243 lekë

Pra shpenzimet totale vjetore për serën e projektuar janë 744 132 lekë ose **6 200** USD

Prodhimet nga sera: çfarë prodhohet, sa prodhohet, sa kushton shitja e prodhimit,

1) Lloji i prodhimit:

Domate: Rendimentet e arritura në sera moderne në vendin tonë janë deri 2000 kv/ha.vit. Ne Greqi arrijnë deri 2 500 kv/ha.vit, ndërsa në Hollandë deri 5 000 kv/ha.vit.

Çmimi masatar i shtijes së domateve në gjashtëmujorin e dytë të vitit 2002 kanë qënë 86.5 leke/kg. Në gjashtëmujorin e parë të vitit 2003 çmimi mesatar ka qënë 135.9 lekë/kg.

Pra për rendiment 2000 kv/ha.vit, për çmim mesatar 111.1 lekë/kg nga prodhimi i serës 1 ha do të sjellë 22 220 000 lekë/vit ose 185 166 USD/vit. Për serën që projektohet, me sipërfaqe 0.05 ha, të ardhurat do të jenë **1 111 000** lekë/vit ose **9 258** USD/vit.

Përfundimisht, për serën e projektuar, për periudhë 15 vjeçare të amortizimit të serës, rezulton:

- Të ardhura 9 258 USD/vit
- Shpenzime 6 200 USD/vit

Kësisoj, ndërtimi i serave me ngrohje me energji gjeotermale është një investim me efektivitet ekonomik. Eshtë e natyrshme, që të ardhurat e serës do të jenë më të mëdha nëse në të do të kultivohen lule ose fidana, përshembull fidana ullinjsh.

Nëse sistemi i ngrohjes duke shfrytëzuar energjinë gjeotermale do të zbatohet në serat ekzistuese, atëhere do të kërkohesh investim vetëm për sistemin ngrohës dhe shpimin e puseve. Në këto kushte, shpenzimet e serës do të jenë 488 966 lekë/vit , ose 4 100 USD/vit, për periudhë 15 vjeçare vetëshlyerje të investimit. Edhe për periudhë 10 vjeçare vetëshlyerje, shpenzimet do të jenë 562 545 lekë/vit ose 4 700 USD/vit, pra investimi është fitim prurës.

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MATERIALI GRAFIK

Fig. 1.

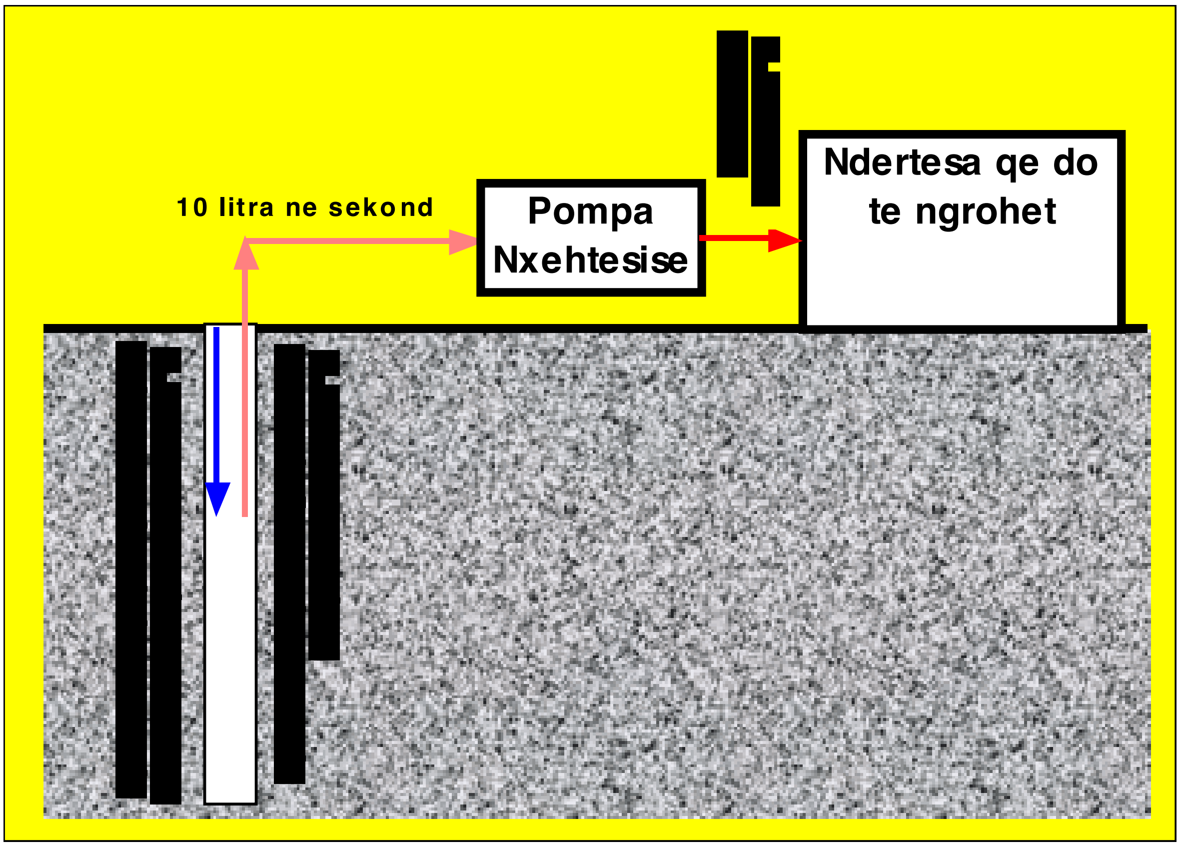
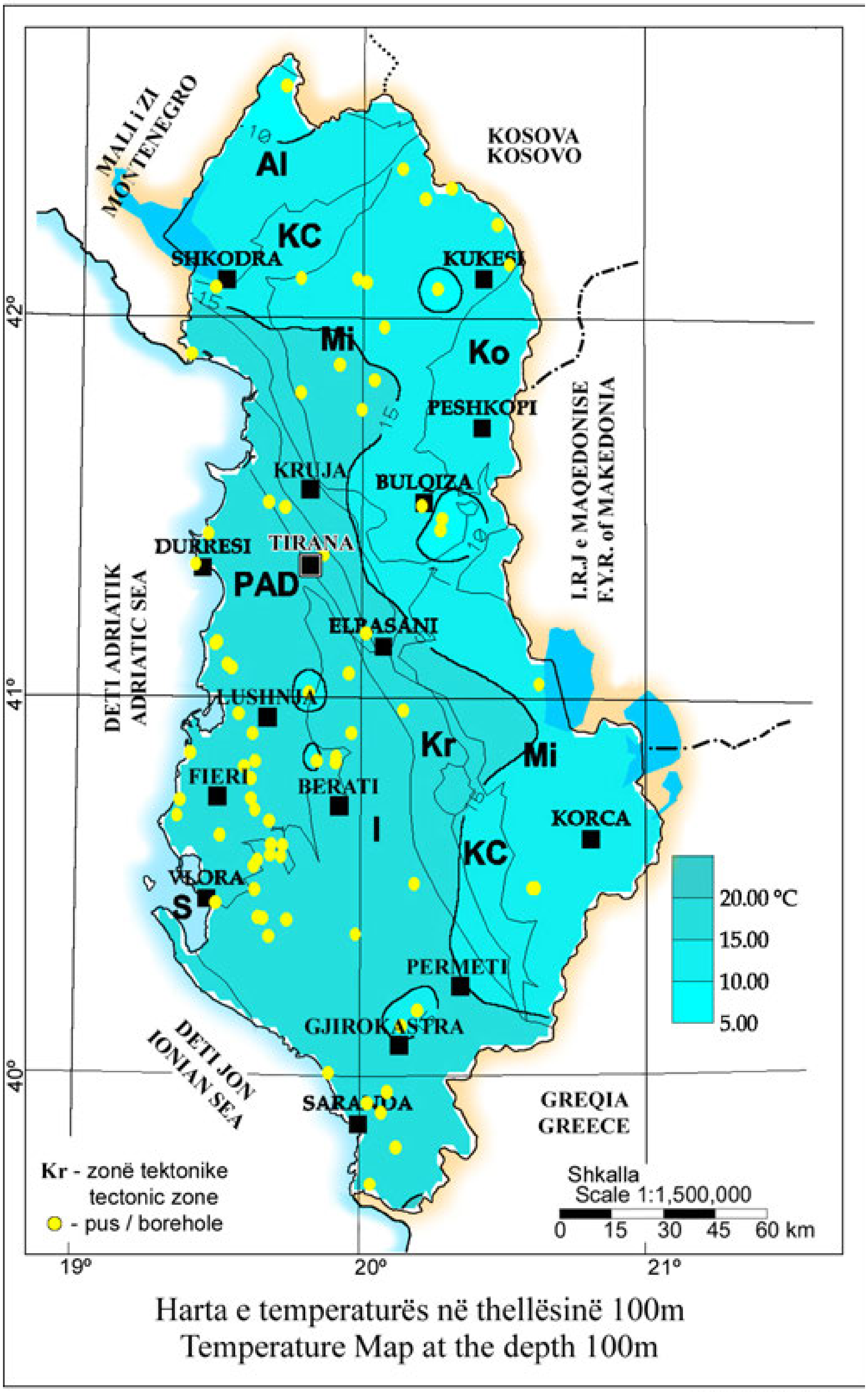
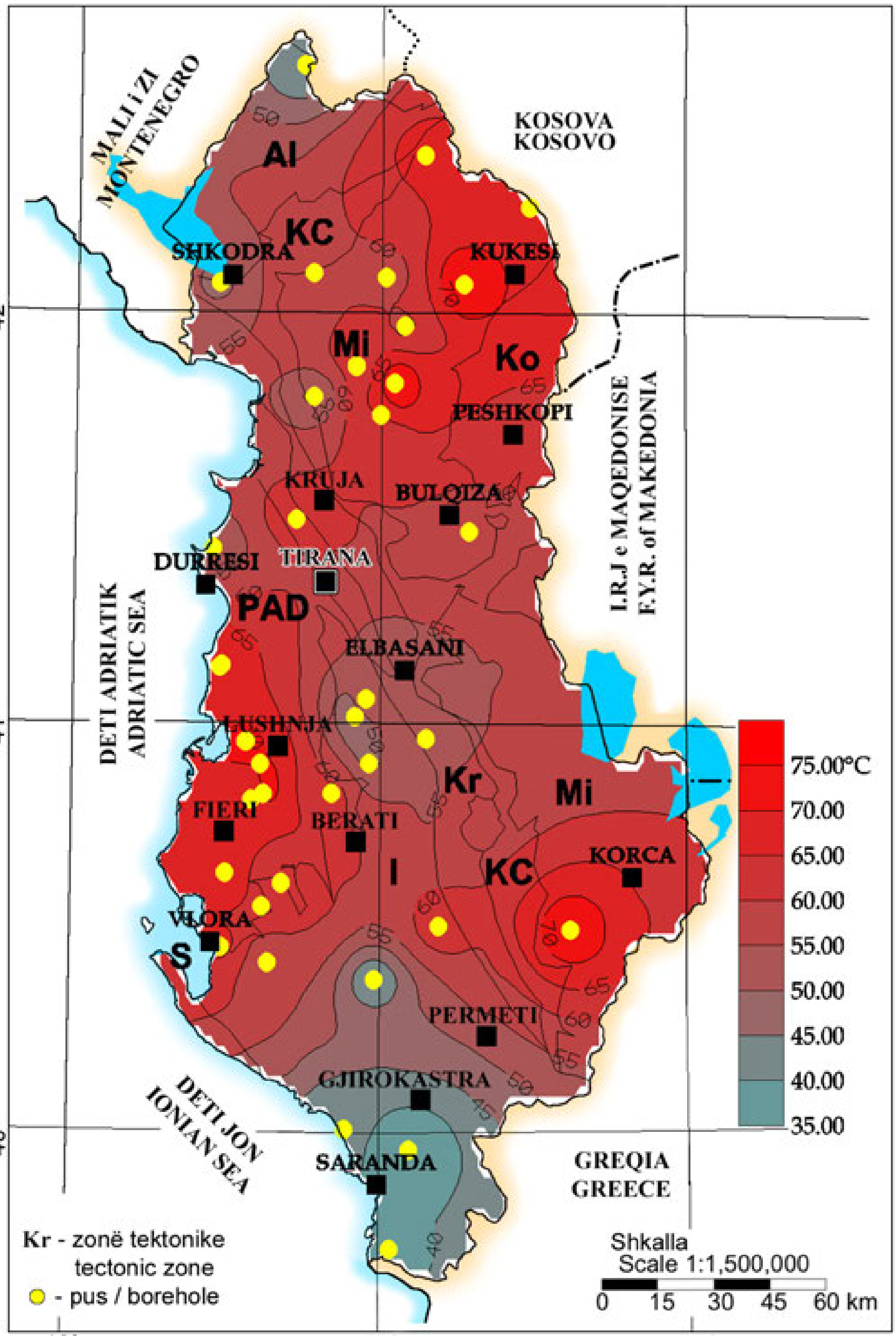


Fig. 2. Skeme e këmbyesit vertikal të nxehtësisë në puset e thellë



Fleta / Plate 7

Fig. 3. Harta e temperaturës së tokës në thellësinë 100 m.



Harta e temperaturës në thellësinë 3000m
Temperature Map at the depth 3000m

Fleta / Plate 12

Fig. 4. Harta e temperaturës së tokës në thellësinë 3000 m.

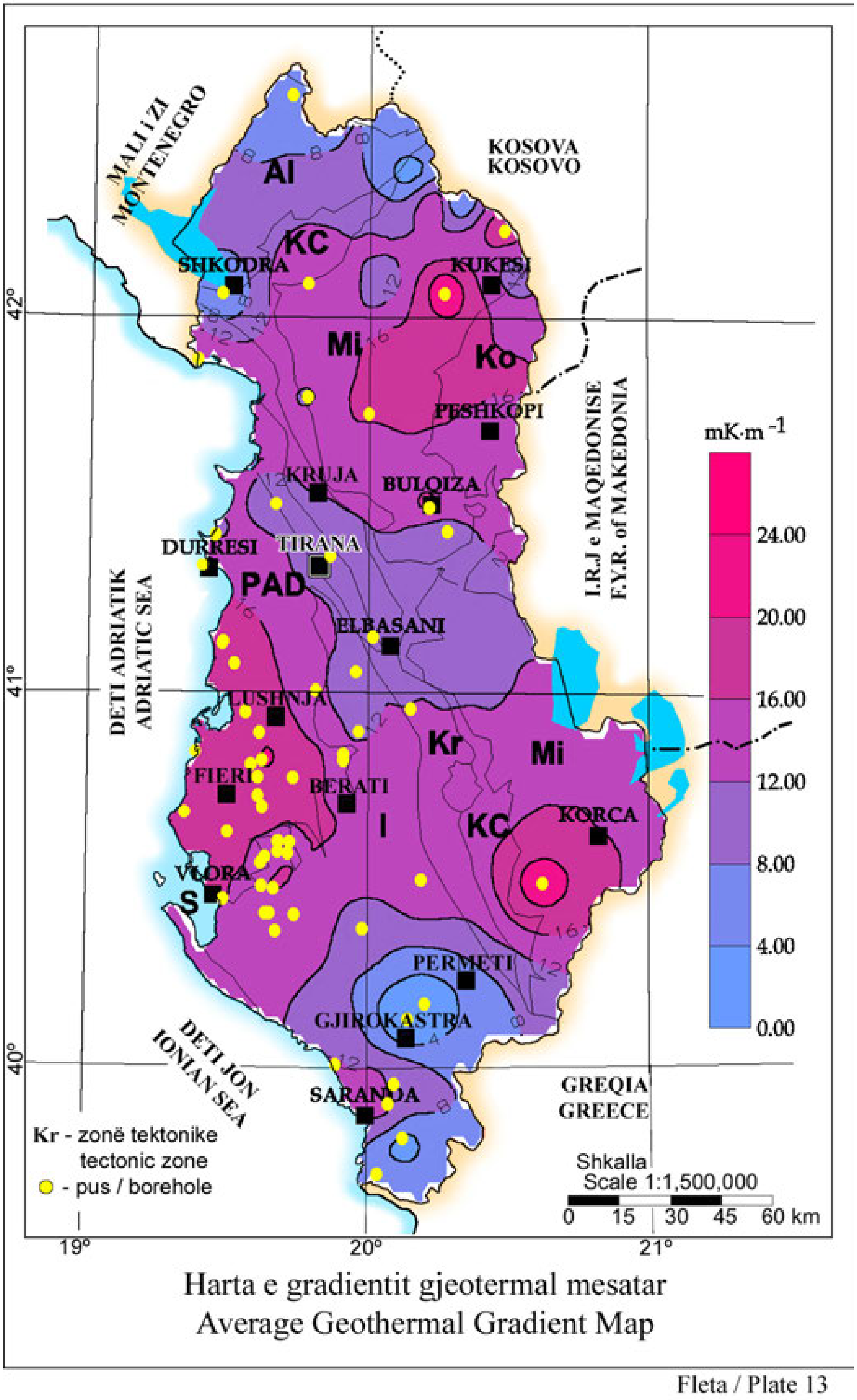
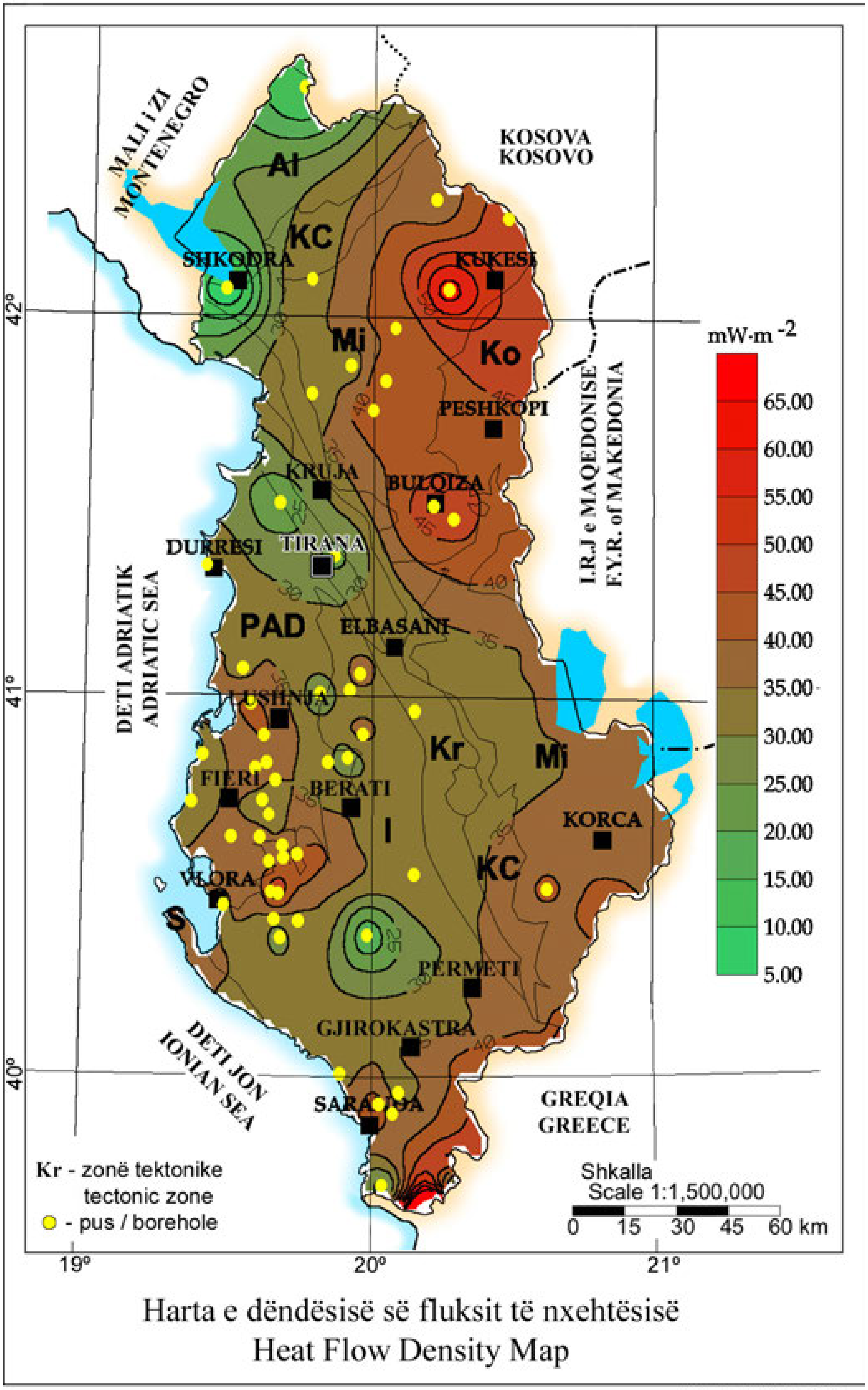


Fig. 5. Harta e gradientit Gjeotermal



Fleta / Plate 16

Fig. 6. Harta e dendësisë së fluksit të nxehtësisë

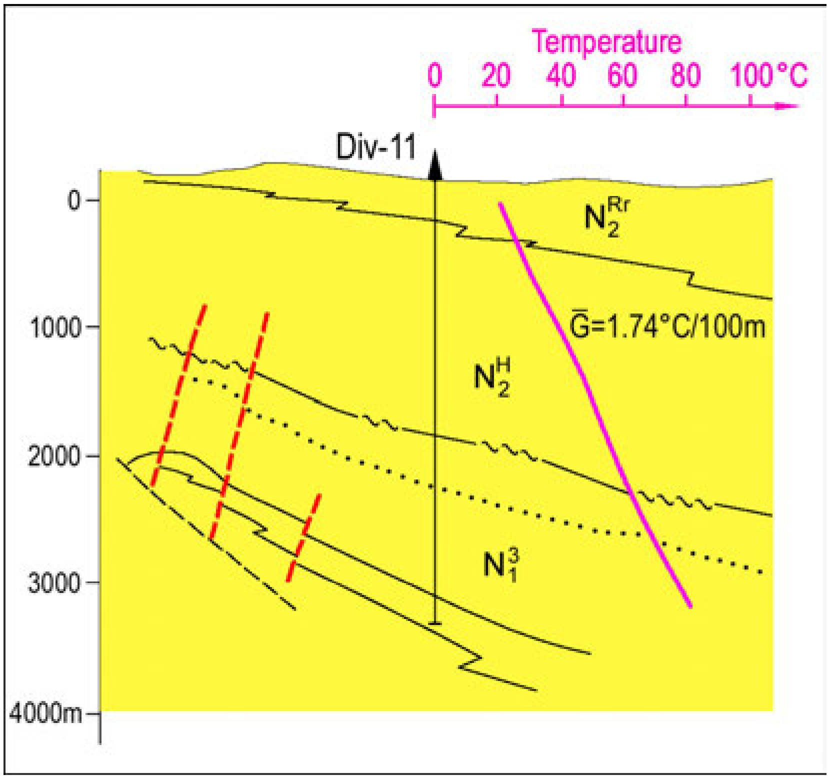


Fig. 7. Profil Gjeotermal në strukturën e Divjakës

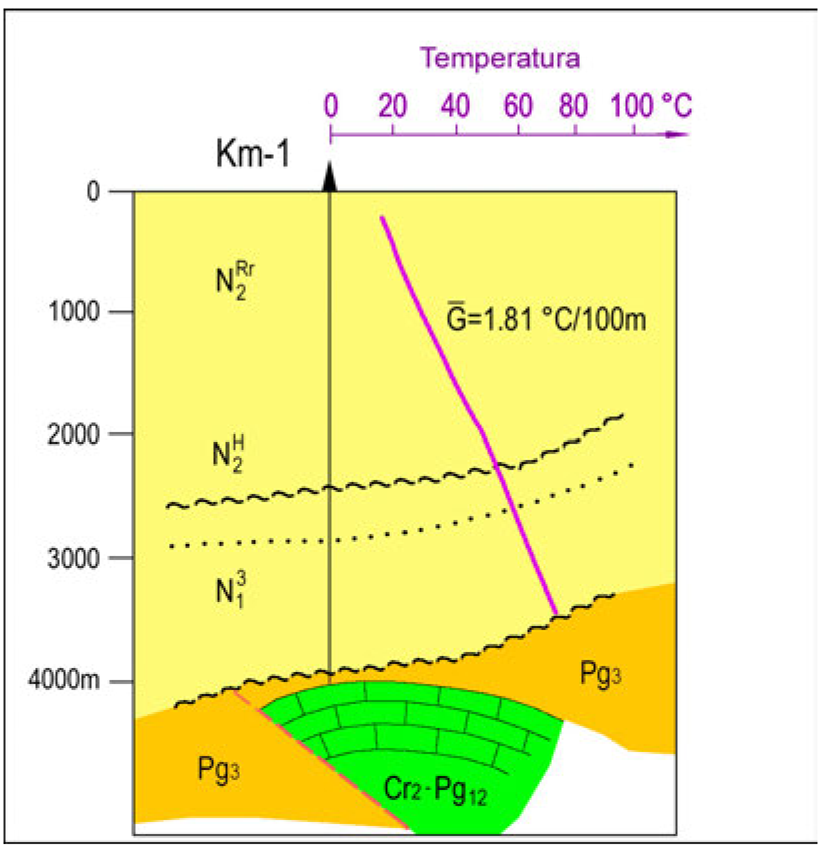


Fig. 8. Profil gjeotermal në Ultësirën Pranadriatike

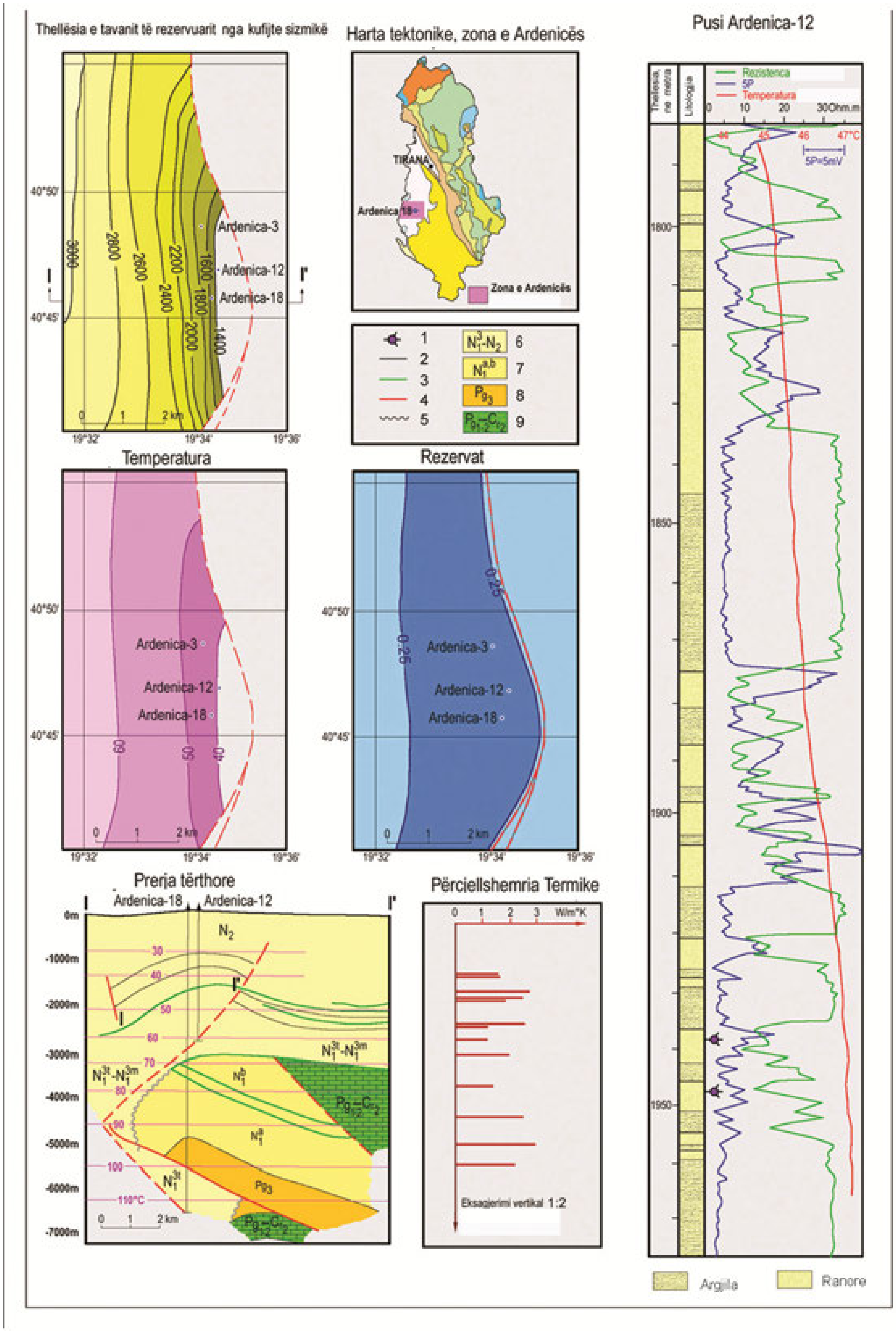


Fig. 9. Puset gjeotermalë në Ultësirën Pranadriatike

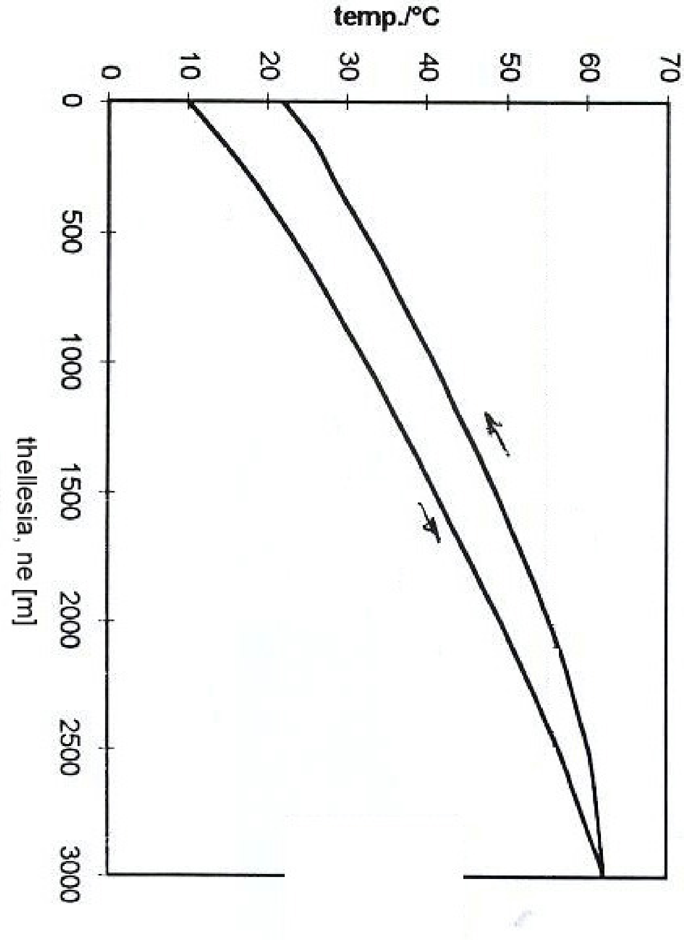


Fig. 10. Termogramat e qarkullimit të ujit të injektuar dhe të përftuar në kërmbyesin vertikal të nxehtësisë, sipas modelimit mathematikor në një pus në Ultësirën Pranadriatike, për dy tipe izolacioni: tub plastik i perforcuar me izolacion xhami dhe për tub me izolacion me vakum të thellë. Tubingu 2” 7/8, debiti 2 m^3/h, temperatura e ujit që injektohet 10^oC, gradienti gjeotermal 0.018 K/m.

Fig. 11. Varësia e temperaturës mesatare dhe numri i ditëve me temperatura të ndryshme, si edhe brezi i kushteve termale të punës në serë.

INTERNATIONAL SUMMER SCHOOL
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POLISH GEOTHERMAL ASSOCIATION
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1.
OUTLOOK ON PRINCIPLES FOR DESIGN OF INTEGRATED AND CASCADE USE LOW ENTHALPY GEOTHERMAL PROJECTS IN ALBANIA

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Abstract

Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters are sulfate, sulfide, methane, and iodinate-bromide types. Thermal sources are located in three geothermal zones:

Kruja geothermal zone represents the zone with the biggess geothermal resources. Kruja zone has a length of 180 km. Identified resources in carbonate reservoirs are 5.9x108-5.1x109 GJ,

Ardenica geothermal zone located in the coastal area of Albania, in sandstone reservoirs.

Peshkopia gjeotermal zone is in the north-eastern area of Albania. Several springs are located there in the disjunctive tectonics belt of the gypsum diapir.

The geothermal situation in Albania offers three directions for the exploitation of geothermal energy:

- **First**ly, thermal sources of low enthalpy are natural sources or wells in a wide territory of Albania. They represent the basis for the successful use of modern technologies for a <u>*complex and cascade exploitation*</u> of this energy, achieving an economical effectiveness:

1. Use by SPA clinics for treatment of different diseases and by hotels for ecotourism.
2. Use by SPA clinics and hotels, greenhouses and aquaculture installations for hot water for heating and sanitary waters.
3. The extraction of chemical microelements.

- **Secondly,** the uses of the heat flow of shallow geological section for heating and cooling of the buildings.
- **Thirdly,** the use of deep abandoned oil and gas wells as "Vertical Earth Heat Probe".

Direct use of the geothermal energy is programmed to be realized using an integrated schema of geothermal energy, heat pumps and solar energy. Energy of the thermal waters will be realized in a cascade way, using it step by step, from high temperatures up to environ-mental temperatures.

Actually, in Albania, the study of the possibilities of exploitation of geothermal energy has begun. The aims of the project are to exa-mine, demonstrate and disseminate the positive technical and financial aspects of the transfer and utilization of innovative geothermal energy technologies in Albania.

Keywords: Geothermal energy, thermal water, geothermal gradient, heat flow.

1. INTRODUCTION

In Albania, a country rich in geothermal resources of low enthalpy and mineral waters, new technologies using of geothermal energy are still untouched. Large numbers of geothermal energy of high and low enthalpy resources, many of mineral water sources, and some CO2 gas reservoirs represent the base for successful application of modern technologies in Albania in order to achieve economic effectiveness and successful exploitation.

Actually, there are many geothermal, hydro-geological, hydrochemical, biological and medi-cal investigations, and studies of thermal and mineral water resources, carried out in Albania. The results of the geothermal studies carried out in Albania are presented in maps and geothermal sections.

Temperature maps have been compiled for different levels of up to 5000m depth.

Geothermal gradient, heat flow density and geo-thermal resources maps have also been developed. Natural springs with thermal waters and the geolo-gical structures with high water tempe-rature have also been mapped. Generally, these investigations and studies are separated each from

the other. Their information and data will be used for studies and evaluations in Albania on a regional scale. These studies and evaluations are necessary to know, in a regional plane, the potential of the thermal and mine-ral water resources and geothermal market of Albania.

According to the results of these new studies, an evaluation for the perspective level of the best areas in the country will be necessary. After this evaluation, it will be possible to begin investment in these areas. Integrated exploitation and cascade direct use of the geothermal energy will be realized by an integrated scheme of geothermal energy, heat pumps and solar energy. This scheme has an environmental benefit by using renewable energies (geothermal energy, solar energy), new technologies (heat pumps) and energy savings (cascade scheme). A cascade scheme should be used to fulfill the thermal energy demand for the selected area in order to get the maximum benefit from geothermal energy.

Exploitation of geothermal energy will have a direct impact in the development of the regions, by increasing their per capita income and, at the same time, ameliorating the standard of living of the people. These investments will be profitable in a short period of time.

2. GEOTHERMAL ENERGY IN ALBANIA

2.1. Methodic

The results of the geothermal studies carried out in Albania are presented in maps and geothermal sections. Temperature maps have been compiled for different levels of up to 5000m depth (Fig. 1, 2). Geothermal gradient, heat flow density and geothermal resources maps have also been drawn up. Natural springs with thermal waters and the geological structures with high water temperatures have also been mapped (Frasheri A. 1992, Frasheri A. et al. 1995). The water basins with higher average temperatures have been studies as well. The study of the possibility of exploitation of abandoned deep oil wells as "Vertical Earth Heat Probes" has already begun.

2.2 Geothermal Features

The Albanides form an integral part of the southern branch of the Mediterranean Alpine orogen. They are subdivided in two zones: the Internal and the External Albanides. The geology of Albanides creates the premise for the research and exploitation of natural geothermal energetic resources.

The greatest heat flow density with a value of 42 mW·m-2 is found in the center of the Preadriatic Depression (Fig. 3). In the east of the ophiolitic belt heat flow density reaches values of up to 60 mW·m-2 .

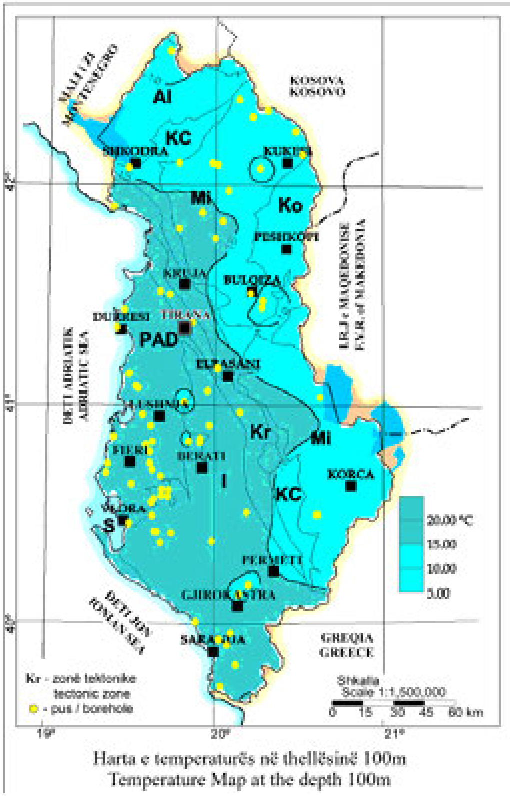

Fig. 1. Temperature Map of Albania, at the depth 100 m.

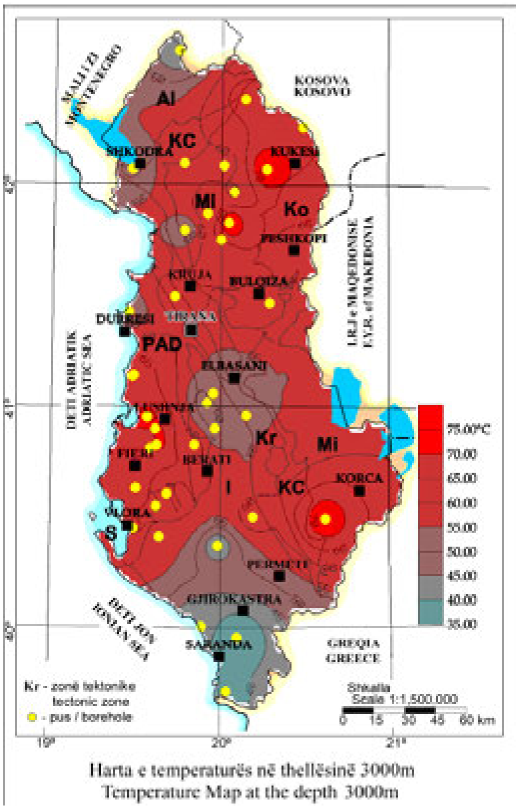

Fig. 2. Temperature Map of Albania, at the depth 3000 m.

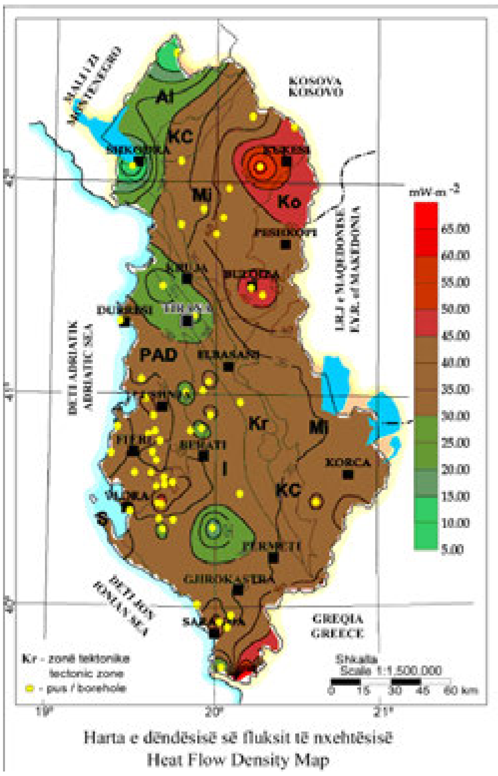

Fig. 3. Heat Flow Density Map of Albania.

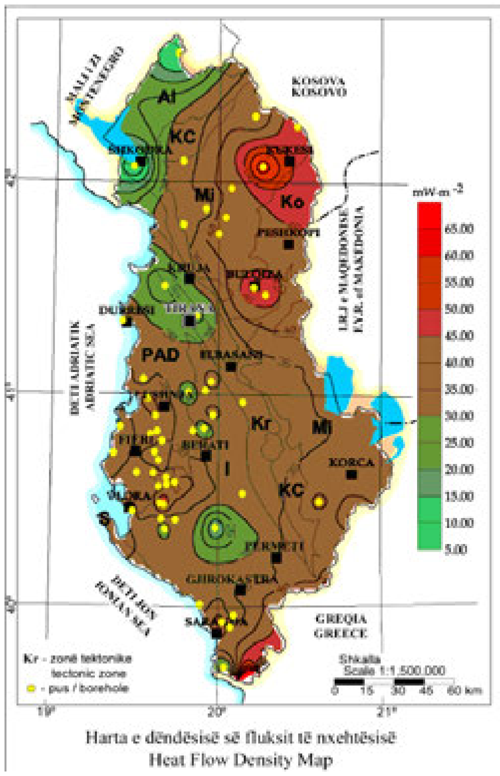

Fig. 4. Geothermal Spring and Wells in Albania

Thermal water sources and wells in Albania Table 1

Type of the source	Location	Tempe-rature (°C)	Salt (mg/l)	Yeild l/sec
Natural Spring	Llixha Elbasan, Peshkopi, Krane (Sarande), Langaric (Permet), Shupal (Tiranë), Sarandoporo (Leskovik), Tërvoll (Gramsh), Mamurras (Tiranë).	21-60	0.3-26	10-40
Deep wells	Peri Adriatic Depression and in the Kruja tectonic zone	29.3-65.5	1-19.3	0.9-18

The temperature at a depth of 100m ranges from 6.7 to 18.8°C, at an average of 16.4oC, and the temperature at the depth of 500m ranges from 21 to 27.7°C.The temperature increases to 105.8°C at the depth of 6000m. In the central

part of the Preadriatic Depression, there are many deep oil wells where the temperature reaches up to 68°C at a depth of 3000m.

The geothermal gradient has the highest value of about 18.7 mK·m-1 in the center of the Peri Adriatic Depression. Elsewhere, the gradient is mostly 15 mK·m-1. In the south of the country, the geothermal gradient has low values of 11.5-13 mK·m-1. Towards the northeastern and southeastern regions of Albania, over the ophiolitic belt, the geothermal gradient increases, reaching a value of 23.5 mK·m-1.

2.3. Geothermal Areas and Reservoirs

In Albania, there are many thermal springs and wells of low enthalpy (Fig. 4, Tab. 1) (Frasheri A. et al. 1997) .

These thermal water springs and wells are mainly near zones of regional tectonic fractures. Generally, the water circulates through carbo-natic rocks of the structures and evaporitic beds at some kilometers of depth. The water from the-se springs contains salt, absorbed gas, and orga-nic matter. Waters are sulphide, methane, iodine-bromium and sulfate types. The waters come from different depth levels (800-3000 m) of li-mestone reservoirs and

sandstone reservoirs. Thermal sources are located in three geothermal zones:

Kruja geothermal zone represents the zone with largest geothermal resources. Kruja zone has a length of 180 km. Identified resources in carbonate reservoirs are 5.9x108-5.1x109 GJ,

Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs.

Peshkopia gjeotermal zone is locaden in the northeastern area of Albania. Several springs are located with disjunctive tectonics of the gypsum diapir.

3. DIRECTIONS FOR THE EXPLOITATION OF GEOTHERMAL ENERGY OF LOW ENTHALPY IN ALBANIA

The geothermal situation of low enthalpy in Albania offers the following directions for the exploitation of geothermal energy, which is unused until now. This exploitation will realized by an integrated scheme of geothermal energy, heat pumps, and solar energy, and cascade use of this energy (Frasheri A. 2000, Frasheri A. et al. 1997).

- **Firstly,** space heating and cooling using ground heat by the Borehole Heat Exchanger (BHE) in the shallow (about 100 m depth) boreholes.

The increased demand in energy for heating and cooling of premises, in the framework of the energy crisis in Albania, represent the great and important problem of the Energy System of Albania. Actually, the electric energy consum-ption for heating is 1 375 GWh/year, or 23.8 % of the total electric energy production in Albania (Fig. 5) (National Agency of Energy, Tirana, 2003). The situation becomes more problematic because the use of natural gas for heating emits large quantities of CO_2 in the atmosphere.

Direct use of ground heat by the Borehole Heat Exchanger-Geothermal Heat Pump repre-sents a modern system for space heating and cooling (Lungt J. W. 1996, Rybach L. et al. 2000, 2004). Two types of shallow heat sources exist: ground heat and underground water heat. Consequently, two kinds of technology can be applied:

Firstly, ground-source and Borehole heat Exchanger-Geothermal Heat Pump or ground-couplet (closed loop),

Secondly: underground water system – Geothermal Heat Pump (open loop). Ground coupling is used where insufficient well water exists or where the quality of the well water is a problem.

In order to make use of this renewable geothermal energy and environmentally friendly ground heat for space heating and cooling in Albania, we have introduced the idea of building a demonstrative installation for heating and cooling purposes in Tirana (Frasheri et al. 2003). It will contribute to solving the problematic issue of heating and cooling of premises in Albania.

- **Secondly**, thermal sources of low enthalpy and of maximum temperature up to 80°C. These are natural sources or wells in a wide territory of Albania, from the South near the Albanian-Greek boundary to Northeast districts in Diber Region.

Thermal waters of springs and wells in Albania may be used in several ways:

Modern SPA clinics can use these for the treatment of different diseases and hotels, can also use these for thermal pools, to further the development of eco-tourism.

Such centres may attract many of clients, including many outside Albania, because of curative properties of these waters and also because they are situated in attractive areas near the sea side, mountains, or Ohrid lake. At the present, some SPA clinics using technology work in some geothermal springs and wells in Albania.

The oldest and most important is **Elbasani Llixha SPA,** which is located about 10 km south of Elbasani city and 61 km south-east of Tirana, in the central part of Albania. By national road communication, Llixha area is connected with Elbasani and Tirana. In the future, this area will be only 10 km from the highway Durresi- Skopje- Sofia- Istanbul, which is projected for construction and nominated as No. 8 European Corridor. This area has the opportunity to be frequented by a large number of people from different countries. These thermal springs from about 2000 years ago are well known. According to historic data, in Elbasani Llixha, thermal springs there have been a centre near of the old road “Via Egnatia" that has passed from Durresi to Constantinople. The number of Albanian patients treated for rheumatism and various illnesses in Elbasani Lixha SPA in maximum are 7899 person/year. All seven groups of the springs in Llixha Elbasani and Kozani-8 well geothermal area will have the possibilities for modern complex exploitation. The beautiful landscape of Elbasani Lixha area can be used not only for medical treatment but also as a tourist destination. This area is located near the very well know Ohrid Lake pearl or mountains Gjinari, with their fantastic forests and nice climate. Ishmi 1/b geothermal well is located in beautiful Tirana field, near the “Mother Theresa” Rinasi (Tirana) Airport, the Adriatic coastline, and Kruja - Skandergeg Mountain.

Benja and Sarandaporo thermal water areas and Postenani steam springs are located near the beautiful Vjosa River valley. Peshkopia geothermal springs area is located near of the Korrabi Mountain, the highest mountain in Albania (2753m). The beautiful landscape of Vjosa valley, near the Albanian-Greek border and Peshkopia area near of Debar region in Macedonia, will not only

be used as a thermal water bearing place for medical treatment, but also as a tourist destination.

2. The hot water can also be used also for heating of hotels, clinics and tourist centers, as well as for the preparation of sanitary hot water used in these facilities. Near these medical clinics and tourist centres, it is possible to build greenhouses for flowers and vegetables, as well as aquaculture installations (Popovki K. and Popovska Vasilevska S. 2002).

3. From thermal mineral waters, it is possible to extract very useful chemical microelements such as iodine, bromine, chlorine, and other natural salts necessary for the preparation of creams for the treatment of many skin diseases as well as for beauty care products. From these waters it is also possible to extract sulphidric and carbonic gas. It is possible to build installations to process of mineral waters.

Consequently, the sources of low enthalpy geothermal energy in Albania, which are, at the same time, the sources of multi-element mineral waters, represent the basis for succes-sful use of modern technologies for a *complex and cascade exploitation* of this energy, achi-eving economic effectiveness. Such develop-ments are also useful for the creation of new working places and the improvement of the standards of living for local communities located near thermal sources.

• **Thirdly,** the use of deep doublet or single abandoned oil and gas wells as the “Vertical Earth Heat Probe”, to obtain geothermal energy. The geothermal gradient of the Albanian Sedimentary Basin has average values of about 18.7 mK·m-1. At 2 000 m depth, the temperature reaches a value of about 48°C. In these single abandoned wells, a closed circuit water system can be installed. Near these wells, greenhouses can be built.

THE PRINCIPLES FOR ALBANIAN GEOTHERMAL ENERGY MARKET ANALYSE AND DESIGN

Actually in Albania the study of the possibilities of exploitation of the geothermal energy has begun. Based on the above analysis, for the best area selected, a Feasibility Study will be performed to analyze three components: energy supply, environmental impact and financial aspects, and to suggest the best solution of the innovative geothermal energy utilization technology applications in that area.

For good preparation of the project and implementation of the project, in detail are determined:

Objectives of the market study for:

1. Space heating and cooling consumers.
2. Consumers for geothermal energy & thermal water integrale and cascade direct use (heat, spa, cooling, power production, drinking water, aquaculture, agriculture)
3. Geological risk, financial possibilities to cover geological risk.
4. Traffic connections.
5. Gathering information material and know-ledge dissemination as very important element of utilization of geothermal energy
6. Significance of the project proposal and its expected achievements

The integrated project includes:

1. Aims and objectives of the project.
2. Construction of the experimental units for exploitation of the geothermal energy:
3. Concrete detailed design for the implementation phase of the project.
4. Construction of thermal supply installations.
5. Application and transfer technology for a complex and cascade exploitation of geothermal waters energy
6. Methodology of project implementation
7. Economical-financial evaluations
8. Repayment of the credit
9. Feasibility Study

4. CONCLUSIONS

1. Albania has the resources of geothermal energy of low enthalpy, which is possible for integrated and cascade direct use as an alternative energy.

2. Resources of the geothermal energy in Albania are;

a) Natural springs and deep wells with thermal water, of a temperature up to 65.5°C.

b) Heat of subsurface ground, with an average temperature of 16.4oC and depth Earth Heat Flow.

3. Construction of the space-heating system, using shallow borehole heat exchanger (BHE)-Heat Pumps systems present the most important direction of the use of geothermal energy in Albania.

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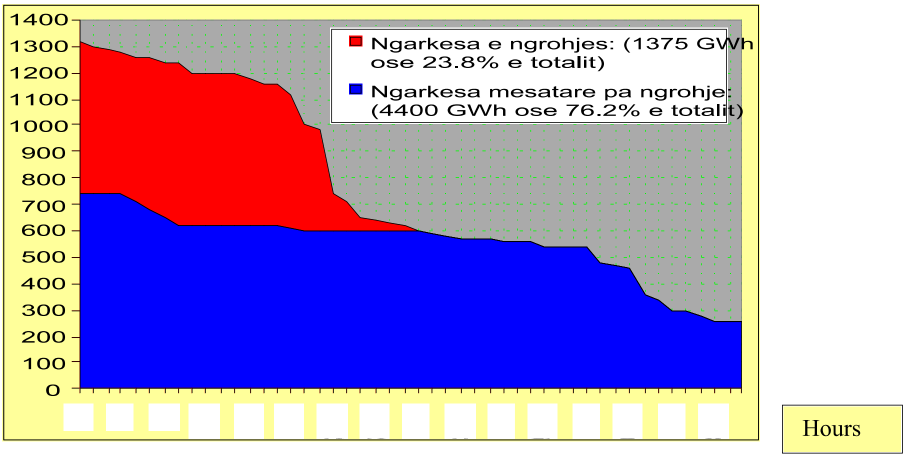

Fig. 5. Annual Electric Power with and without heating, 1999. (National Agency of Energy)

E028 RESISTIVITY SURVEYS – EFFECTIVE METHOD FOR INTEGRATED GEOELECTRICAL EXPLORATION IN ALBANIA

HOMAGE TO THE C. SCHLUMBERGER

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Fifty years ago for me, an 18 years old electric technician, started work in Well-Logging Service of Albanian Oil and Gas Industry, the Schlumberger brothers name has been equivalent to the geophysics one. Today, after a half of century experience for the geoelectrical exploration and forming of the geophysical engineers, I'm concluded that resistivity method, proposed by C. Schlumberger many tens of years before, has demonstrated high effectiveness in the different exploration domains, and always is in the front of geoelectrical surveys. Analyse of the geoelectrical surveys results by resistivity method in Albania is presented in the paper.

DIRECTION OF THE RESISITIVITY METHOD APPLICATIONS IN ALBANIA

Apparent resistivity method, for half a century, is an important element of the integrated geophysical surveys, with high accuracy and discrimination capabilities:

- **Borehole logging**: for oil and gas deep wells and shallow boreholes for coil exploration.

There are used gradient arrays B0.1A0.5M; B0.1A0.45M, B0.1A0.95M, B0.2A1.9M, B0.4A3.3M and B0.7A7.65M and potential arrays M0.25A2B, M4A40B, M8A40B, which from 1952 are represented the base arrays and important elements for electrical borehole logging in oil and gas industry. B0.2B1.9M and M0.25A2B represent standard normal arrays. Particularly, by all these arrays were realised lateral electrical soundings. Arrays B0.1A1.95M and M1.95A0.1B are used for coal boreholes logging.

- **Geoelectrical surveys**: In Albania, the electrical soundings and profiling by Schlumberger array AMNB, were successfully used for solving of following geological problems:

1) Marine Electrical Soundings, with depth of investigation about 2500 m and depth of influence 3500 m, by current electrode spacing up to 16 km, in the Albanian Adriatic Shelf:

- Exploration of shallow oil and gas bearing molasses structures in the Albanian Adriatic Shelf, having geoelectrical markers as top of Pliocene clay and Tortonian and Serravalian sandstone pack.
- Mapping of eroded fold flanks covered by loose Quaternary marine deposits or sea waters.
- Exploration of littoral heavy minerals placers.
- Mapping of loose Quaternary deposits.

2) Onshore Electrical Soundings, for:

- Method in the integrated oil and gas exploration, for lithological identification of seismic reflectors from carbonate anticline tops, and for the sandstone packs of the Neogene's molasses structures mapping.

- Engineering investigations of construction areas, raw materials dams, slope stability and landslides, traces of the highways, railways, tunnels and main irrigation channels.
- Hydrogeological Exploration.
- Karst zones and cavities investigations.
- Environmental investigations: Underground waters aquifer and soil pollutions.
- Solid mineral exploration: copper minerals deposits, high, rare and precious placers, coal basin tectonics, bauxites etc.

3) Electrical profiling:

Marine profiling: For Quaternary loose sediments and outcrops of the Neogene's molasses sea bottom mapping. Profiling was carried out by differential array MAN, $B \rightarrow \infty$, axial dipole array ABMN, and pole-dipole array AMN, $B \rightarrow \infty$, with a spacing 100-400 m.

Onshore profiling: with Schlumberger multiple arrays $A_1A_2MNB_2B_1$ for geoelectrical mapping of the contacts between volcanic and sedimentary rocks in Lower-Middle Triassic volcanic sedimentary pack, last ones with Upper Triassic limestone, tectonic faults etc. Pole-dipole array for combined profiling AMNB, $C \rightarrow \infty$ was used for massive structure of copper minerals bodies exploration.

Results of the electrical soundings and profiling by Schlumberger array in Albania, in the paper are analysed.

RESULTS AND DISSCUSIONS

Marine electrical soundings and profiling, as a part of integrated marine geological-geophysical oil and gas exploration, along Albanian Adriatic Shelf from Vlora Bay at the south to Shengjini Bay at the north, were used for mapping, within a distance of 10 km from the coastline, where the sea depth reaches about 50 m. Averagely, sea depth was 10-20 m. of the this marine space.

The Durresi structure exploration represents a successfully example of marine resistivity sounding and profiling application. Based on this exploration have been drilled a deep well Du-16 which has been discovered a gas deposit; under the Adriatic Sea water structure (Fig. 1,2).

Durrës – Kepi Pallës area is characterized by a presence of Neogene's molasses formation: Tortonian clay-sandstone, Messinian clay, sandstone interbeds and lens, and gypsum debris and blocks stage and Pliocene clay deposits. Up to present, by deep wells, is known that 2975-3125 m is thickness of Neogene molasses. Marine Quaternary loose deposits have covered bedrocks of the neogene molasses. These deposits are extended in the shallow offshore in Durresi-Kepi Palles area, and are presented by loose sand in the coastal line and clay mud far from coastline. Marine deposit thickness in the offshore are is 10 m near of the coastline in the Kepi Palles sector, which increased up to 20-50 m at the west.

Durrës-Kepi Pallës anticline is asymmetric and structure top is extended about 1600 m at the west of the coastal line, under the Adriatic Sea waters (Fig. 1, 2). After Pliocene field extension, about 40 km is length of the structure, and 2 km width. The anticline amplitude is varies of 2000 up to 2500 m. Eastern flank is tectonically abrupt. Part of eastern limb of the structure has a dipping 45-55^o in the western location from tectonic line. At the depth, the dipping gradually is increased to 75-80^o up to overturned. At the surface, the tectonic line is outcropped at Kepi Pallës on shore. The tectonic line is located under Adriatic Sea waters toward the Porto Romano sector.

Tortonian sandstone packs of the eastern anticline flank, covered by marine Quaternary loose deposits, are mapped by electrical profiling (Fig. 2).

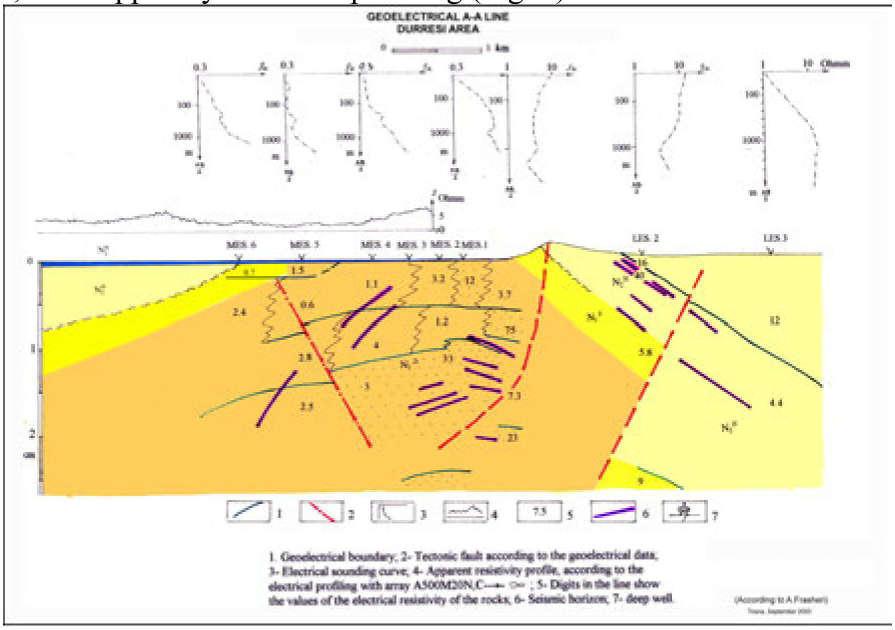

Fig. 1. Geological-geophysical profile, Durresi gas bearing structure.

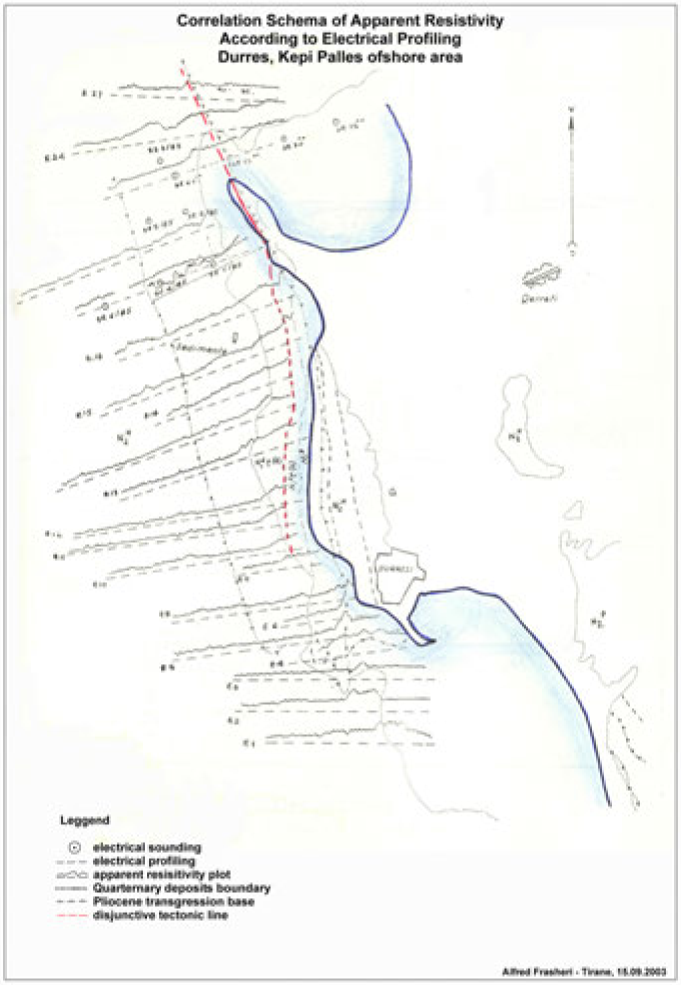

Fig. 2. Geoelectrical marine mapping of offshore eastern flank of Durredi anticline.

Slope stabilization and landslides investigations have been realized successfully by integrated geophysical methods, which electrical soundings present an important method (Fig. 3).

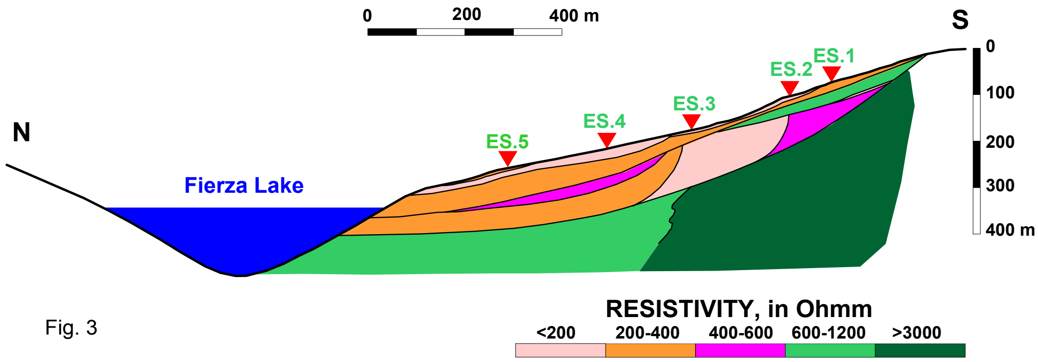

Fig. 3. Geoelectrical section of Porava landslide.

Porava landslide is located in the lakeshore of the Fierza hydropower plant lake. Fig. 3 shows presence of two categories of geoelectrical markers in the profile, which are determined full configuration of the sliding structure in the rocks of the volcanic sedimentary section. In the karstified zones , the geoelectrical section is KH type. Depending on the thickness of layers, A type geoelectrical section is also possible. Karstified surface forms, which are filled with residues of the altered material has a resistivity of first layer is smaller than that of the second layer, represented by karstified limestones with empty lattices. The third geoelectrical layer shows the resistivity is lower that of the second layer. This is because the less dense karst lattice is filled with water or clay. The fourth geoelectrical layer is represented by compact limestone, and consequently its resistivity is higher than that of all overlying layers.

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RESISTIVITY SURVEYS - EFFECTIVE METHOD FOR INTEGRATED GEOELECTRICAL EXPLORATION IN ALBANIA

Tribute to the brothers Conrad and Marcel Schlumberger

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Përmbledhje

Ky artikull është referuar në Konferencën Ndërkombëtare të 65-të Bashkimit Europian të Gjeoshkencëtarëve dhe Inxhinjerëve (EAGE) në Paris, qershor 2004.

Pesëdhjetë e një vjet më parë, për mua, teknikun elektrik 18 vjeçar, që filloi punën si operator i karotazhit në indsustrinë e naftës dhe të gazit në Patos, mbiemëri i vëllezërve Shlimberzhe ishte i barazvlefshëm me gjeofizikën. Sot, pas gjysëm shekulli përvoje për kërkimet gjeoelektrike dhe përgatitjen e inxhinjerëve gjeofizikë, kam arrtitur në përfundim se metoda e rezistencës, e propozuar nga vëllezërit Konrad dhe Marsel Shlimberzhe në fillimin e shekullit të 20-të, ka demostruar efektivitet të lartë në fusha të ndryshme të kërkimit, dhe përsëri sot ndodhet në frontin e kërkimeve gjeoelektrike moderne. Analiza e kërkimeve gjeoelektrike në Shqipëri paraqiten në këtë artikull. Eshtë në nderin e gjeofizikëve shqiptarë që e kanë zbatuar dhe zhvilluar me sukses këtë metodë në kushtet e ndërtimit gjeologjik të Albanideve.

Në referat janë analizuar dhe paraqitur 32 raste nga rezultatet e përdorimit të metodës së rezistencës në Shqipëri gjatë 50 vjetëve të fundit; për arsye vendi në këtë artikull po analizohen vetëm gjashtë raste.

Abstract

This paper is presented at 65th Conference and Exhibition of European Association of Geoscientists and Engineers (EAGE), Paris 2004.

Fifty-one years ago, for me, the 18 years old electric technician, starting the work as a well-logging operator at the Well-Logging Service of Albanian Oil and Gas Industry, the name of Schlumberger brothers use to be equivalent to that of geophysics. Today, after half a century experience in geoelectrical prospecting and in the education of the geophysical engineers, I believe that the resistivity method, proposed by brothers Conrad and Marcel Schlumberger, many tens of years ago, has demonstrated high effectiveness in various prospecting/exploration situations, and still stands in the front of the modern geoelectrical surveys. A summary presentation of the main geoelectrical survey results in Albania is shown in the paper. It has been an honour for the Albanian geophysicists to successfully apply and develop the resistivity method in the geological setting of Albanides.

In the Conference were presented and analyzed 32 case histories from these results of the last 50 years; in the published paper are presented only six cases due to limited publishing space.

1. History of resistivity method applications in Albania

First applications of the resistivity method in Albania have been reported in 1934, for shallow electrical soundings performed with Schlumberger array, by current electrode spacing 820m, in oil and bitumen exploration in Kuçova and Selenica areas, and resistivity well logging in shallow oil wells (1935), carried out by the Italian geophysicists of A.I.P.A. Company, project leader A. Belluigi, A. Baglio, and Eng. C. Sq., (A.I.P.A. 1934, Biçoku T. 1964, 2004).

The application of deep electrical resistivity soundings in oil and gas exploration have been started in 1950, by Baranov I.A., a Russian and Albanian geophysicists Teki Biçoku and Hasan Topçiu (Baranov I.A.). At the same period have been started the integrated electrical well logging of the oil weep wells (1951), by Russian operator David A. Bronshtein and Albanian operators Hamdi Bejtja, and Alfred Frashëri (1953) (Frasheri, 1964).

Geoelectrical surveys in search for solid minerals have started in 1953 with electrical resistivity profiling in cooper ore exploration in Derveni area (Maroçkina Z.P. 1953). From 1958 the resistivity surveys included many copper bearing zones in the Mirdita areas by the Russian V.M. Pogrebinskiy and the Albanian geophysicists Ligor Lubonja and Alfred Frashëri (Pogrebinskiy, 1959). During the sixties, the Albanian geophysicists Ligor Lubonja, Alfred Frashëri, Esat Daja, Radium Avxhiu, Mihallaq Malaveci, and later in seventies up to present, Përparim Alikaj, Spartak Kasapi, Llesh Prenga, Pirro Leka, Fatmir Duli, Idriz Jata, Sami Nenaj, etc. have successfully applied the electrical profilings and soundings in search for copper/gold sulphide deposits, placers for heavy, rare and precious minerals. The year 1961 represents the beginning of the first integrated geophysical exploration in placers of the rare and precious minerals (Ligor Lubona and Alfred Frashëri). From 1959 we have carried out shallow borehole resistivity logging in solid minerals exploration and development by the Russians (Murat Tokmulin) and the Albanian geophysicists (Neim Çavani from 1963, Sillo Muçko 1964, Violeta Murati from 1973).

The years sixties and seventies presented a period of successful and broad range applications of the resistivity methods. In 1975 re-started the geoelectrical survey with deep electrical soundings in oil and gas exploration (Frashëri A., Jani Lefter, Ciruna Kozma, 1982). In this period Ligor Lubonja, Alfred Frasheri, Mihallaq Malaveci and Thimi Nathanaili have investigated other solid minerals like bauxites with the IP/Resistivity Schlumberger soundings and gradient array. In early eighties the resistivity method was experimented and applied in chrome exploration as well by Fatmir Duli, Llesh Prenga, etc.

In 1961 was carried out the first electrical soundings by the Chinese and the Albanian (Zoto Rjepaj and Sillo Muçko) geophysicists in engineering geology studies with the Schlumberger array, for soil investigation in the industrial building construction area in Fier city and in the riverbed investigation at the dam of Vau Dejës hydropower station. First electrical profiling and soundings in the archaeological exploration have been carried out in the Margëlliçi Ancient Castle (Alfred Frashëri and Radium Avxhiu). At the present, Vladimir Kavaja is successfully continuing the geoelectrical exploration in many important archaeological sites in Albania, as in Apolonia, Butrint, etc.

The year 1975 has opened a new era in Albanian geoelectrical resistivity surveys, recording the performance of the first experimental marine electrical profiling in the Albanian Adriatic shelf for oil and gas exploration by Alfred Frashëri, Radium Avxhiu, Përparim Alikaj, Spartak Kasapi (Frasheri et al. 1977). Based on this experimental study the marine geoelectrical survey expedition was set up in Albania in the late seventies (Alfred Frashëri, Vasillaq Leci). In

1982 was carried out the first deep marine electrical sounding with a Schlumberger array up to AB/2= 8 km, at a sea depth of 50 m. The marine geoelectrical station has been designed, constructed and set up for a power of 250 kW by Alfred Frashëri, Reis Çani, Ymer Luga, Franc Malo and Burhan Çanga (Frasheri et al.1980).

The performance of a broad spectrum of resistivity surveys has been increasingly based on computer data processing and interpretation. In 1974 started the first computer programming and processing of the electrical survey data, which continued to grow in years by Alfred Frashëri, Gudar Beqiraj, Neki Frashëri, Ylli Vejsiu, Dhimitër Tole, Radium Avxhiu, Nehat Likaj, Ivoni Çani (Frasheri et al. 1974, 1976, 1979, 1984). In 1978, Përparim Alikaj proposed a new survey method called IP/Resistivity "Real Section" based on scale modeling and field experimental surveys using the multiple gradient and Schlumberger arrays and the concept of depth of investigation. Several deep mineralized structures were discovered in Albania with this method (Langore L., Alikaj P. and Gjovreku D.1989). The last 14 years P. Alikaj has further developed and successfully applied the method in base metals and gold exploration, mostly in Canada but in other parts of the world as well (Alikaj P. and Morrison D.F. 1997). The years eighties was been period fo the intensively studies and experiments for increasing of the depth of investigation, up to 800-1000m, using underground geoelectrical surveys in the boreholes (Lubonja et al. 1984, Frasheri et al. 1995).

The electrical soundings and resistivity borehole loggings have been used extensively in groundwater investigations in Albania by Pëllumb Haxhiaj, Nexhip Maskaj and Genc Kallfa. (Frasheri 1983).

Karst zones investigations using profilings and soundings with the Schlumberger arrays have been used since 1984 in irrigation reservoir areas by Alfred Frashëri, Ludvig Kapllani, Burhan Çanga (Frasheri 1982).

The last decade has been a period of intensive developments in engineering and environmental integrated geophysics, where the resistivity represents the main method. In 1997 was completed with our home made program the 2D Resistivity Tomography for a raw material dam and a landslide investigation by Alfred Frashëri, Ludvig Kapllani (Frasheri et al. 1997, 1999). At present, the resistivity method in Albania is vastly being used to solve various geological engineering and environmental tasks (Alfred Frashëri, Përparim Alikaj, Radium Avxhiu, Pirro Leka, Llesh Prenga, Burhan Çanga, Sami Nenaj, Vladimir Kavaja, Idriz Jata, Fatbardha Vinçani, etc.).

2. Direction of the resistivity method applications in Albania

Apparent resistivity method, for half a century, is an important element of the integrated geophysical surveys in Albania, with high accuracy and discrimination capabilities:

- **Borehole logging**: for oil and gas deep wells and shallow boreholes for coil exploration.

There are used gradient arrays B0.1A0.5M; B0.1A0.45M, B0.1A0.95M, B0.2A1.9M, B0.4A3.3M and B0.7A7.65M and potential arrays M0.25A2B, M4A40B, M8A40B, which from 1952 are represented the base arrays and important elements for electrical borehole logging in oil and gas industry. B0.2B1.9M and M0.25A2B represent standard normal arrays. Particularly, by all these arrays were realised lateral electrical soundings. Arrays B0.1A1.95M and M1.95A0.1B are used for coal boreholes logging.

- **Geoelectrical surveys**: In Albania, the electrical soundings and profiling by Schlumberger array AMNB, were successfully used for solving of following geological problems, as important method of the integrated geophysical surveys:

1) Onshore Electrical Soundings, for:

- Method in the integrated oil and gas exploration, for lithological identification of seismic reflectors from carbonate anticline tops, and for the sandstone packs of the Neogene's molasses structures mapping.
- Engineering investigations of construction areas, raw materials dams, slope stability and landslides, traces of the highways, railways, tunnels and main irrigation channels.
- Hydrogeological Exploration.
- Karst zones and cavities investigations.
- Environmental investigations: Underground waters aquifer and soil pollutions, soil and bedrocks degradation.
- Solid mineral exploration: copper minerals deposits, high, rare and precious placers, coal basin tectonics, bauxites etc.

2) Marine electrical soundings in the Albanian Adriatic Shelf were a part of integrated marine geological-geophysical for oil and gas exploration. Marine Electrical Soundings have a depth of investigation about 2500 m and depth of influence 3500 m, the current electrode spacing up to 16 km, the maximal distance from the coastline 10 km, averagely sea depth 10-20 m and maximal sea depth about 50 m.

Marine electrical soundings have the geological tasks:

-. Mapping of the Neogene molasses structures in the Albanian Adriatic Shelf.-. Exploration of shallow oil and gas bearing Neogene molasses in the Albanian Adriatic Shelf, having geoelectrical markers as top of Pliocene clay and Tortonian and Serravalian sandstone pack.

-. Mapping of eroded fold flanks covered by loose Quaternary marine deposits or seawaters.

-. Exploration of littoral heavy minerals placers.

-. Mapping of loose Quaternary deposits.

3) Onshore electrical profiling with Schlumberger multiple arrays $A_1A_2MNB_2B_1$ for geoelectrical mapping of the contacts between volcanic and sedimentary rocks in Lower-Middle Triassic volcanic sedimentary pack, last ones with Upper Triassic limestone, tectonic faults etc. Pole-dipole array for combined profiling AMNB, $C \rightarrow \infty$ was used for massive structure of copper minerals bodies exploration.

Resistivity tomography is used for the solving of engineering investigations, hydrogeological exploration, karst zones and cavities investigations, environmental investigations and archaeological research.

4. Marine profiling, for:

- Quaternary loose sediments and outcrops of the Neogene's molasses sea bottom mapping.
- Mapping of eroded fold flanks covered by loose Quaternary marine deposits or sea waters.
- Exploration of littoral heavy minerals placers.
- Mapping of loose Quaternary deposits.

Profiling was carried out by differential array MAN, $B \rightarrow \infty$, axial dipole array ABMN, and pole-dipole array AMN, $B \rightarrow \infty$, with a spacing 100-400 m.

3. Results and discussions

3.1. Solid minerals exploration

Resistivity profiling have been important method of the integrated geophysical surveys for exploration of the sulphide cooper mineral deposits, heavy, rare and precious placers, bauxites, etc. Surveys are performed by Schlumberger arrays: Symmetric multiple arrays $A_1A_2MNB_2B_1$ and pole-dipole combined arrays profiling AMN, $C\rightarrow\infty$, MNB, $C\rightarrow\infty$.

3.1.1. Massive sulphide cooper deposits exploration:

The most typical and distinctive physical properties are induced polarization chargeability and resistivity, which are conditioned by mineral content, structure and degree of rock alteration. Massive sulphide ores have a minimal resistivity 0.1 Ohmm up to 30 Ohmm. Surrounding magmatic rocks has a average resistivity 200-1200 Ohmm. Schistose detritus overburden with clays and silica has a average resistivity about 20 Ohmm. This property serves as base for application of resistivity methods using by pole-dipole combined arrays profiling AMN, $C\rightarrow\infty$, MNB, $C\rightarrow\infty$.

Between many tens of the case histories of geoelectrical exploration of the cooper deposits in Albania, following three objects in different time periods, depending from the depth of investigation.

In the fig 1 is presented a geological-geophysical section in the Gjegjani massive sulphide deposit at northeaster region of Albania. Based on geoelectrical and geological surveys, Pogrebinsky S.A etc. have designed the borehole that has discovered the cooper deposit (In 1959), which has been one of most important in Albania. Ore body is located in diabase individualization of Lower-Middle Triassic volcanic-sedimentary pack. Over the ore body is observed complex geophysical anomalies. Resistivity anomaly is important element of this anomalous complex. Resistivity anomaly represents a crossing of the resistivity graphics surveyed by both arrays AMN, $C\rightarrow\infty$, MNB, $C\rightarrow\infty$.

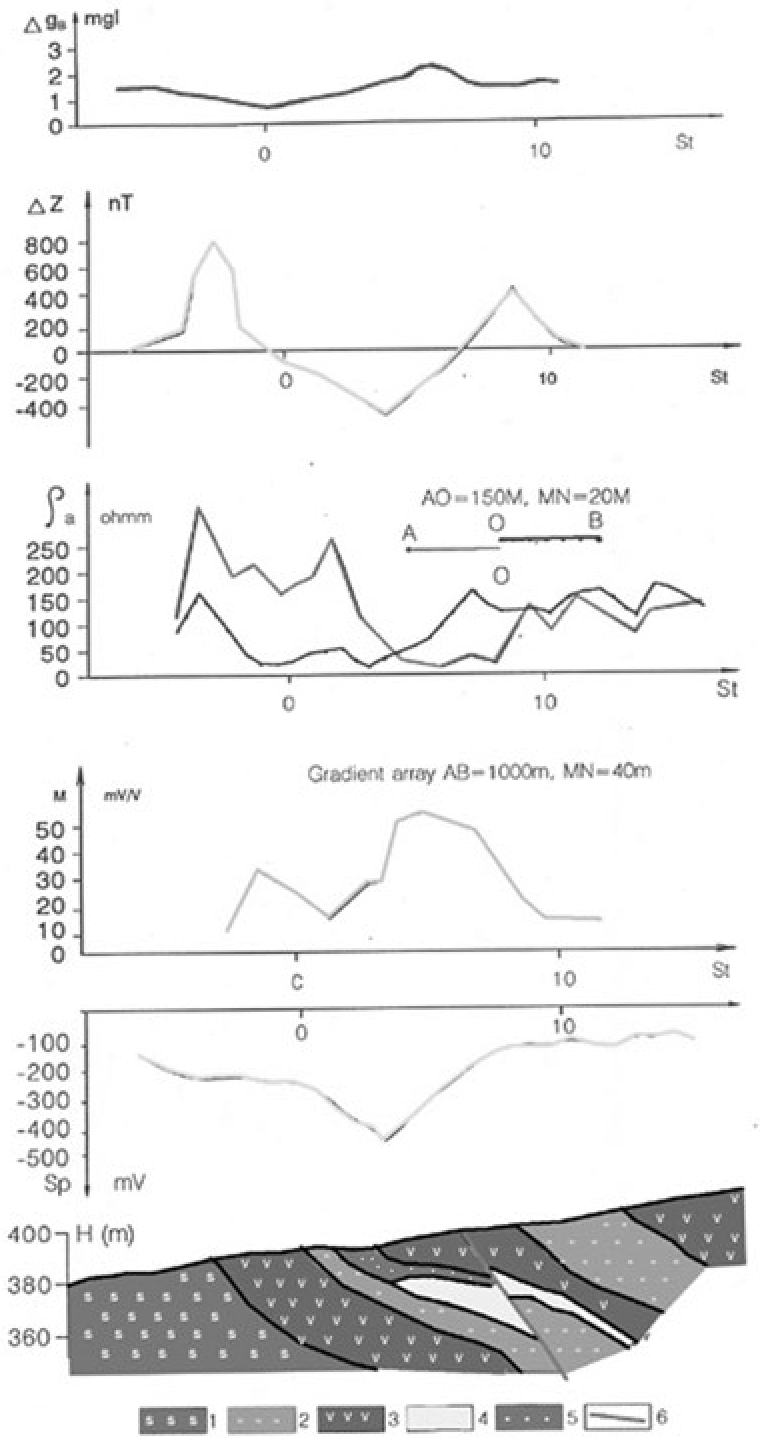

Fig. 1. Geological-geophysical section in the Gjegjani massive sulphide deposit (Compiled by Frasheri A after Pogrebinkiy S.A., Mihayllovskiy J.A. and Boronayev V.A. data).

1- Ultrabasic rock; 2- Argillaceous schists; 3- Diabase; 4- Massive ore body; 5- Disseminated mineral zone; 6- Tectonic faults.

After rapid development in the early 1970s, the IP method in the complex with resistivity and self-potential method became the major surveying method for cooper sulphide exploration, in particular for massive ore bodies (Fig. 2).

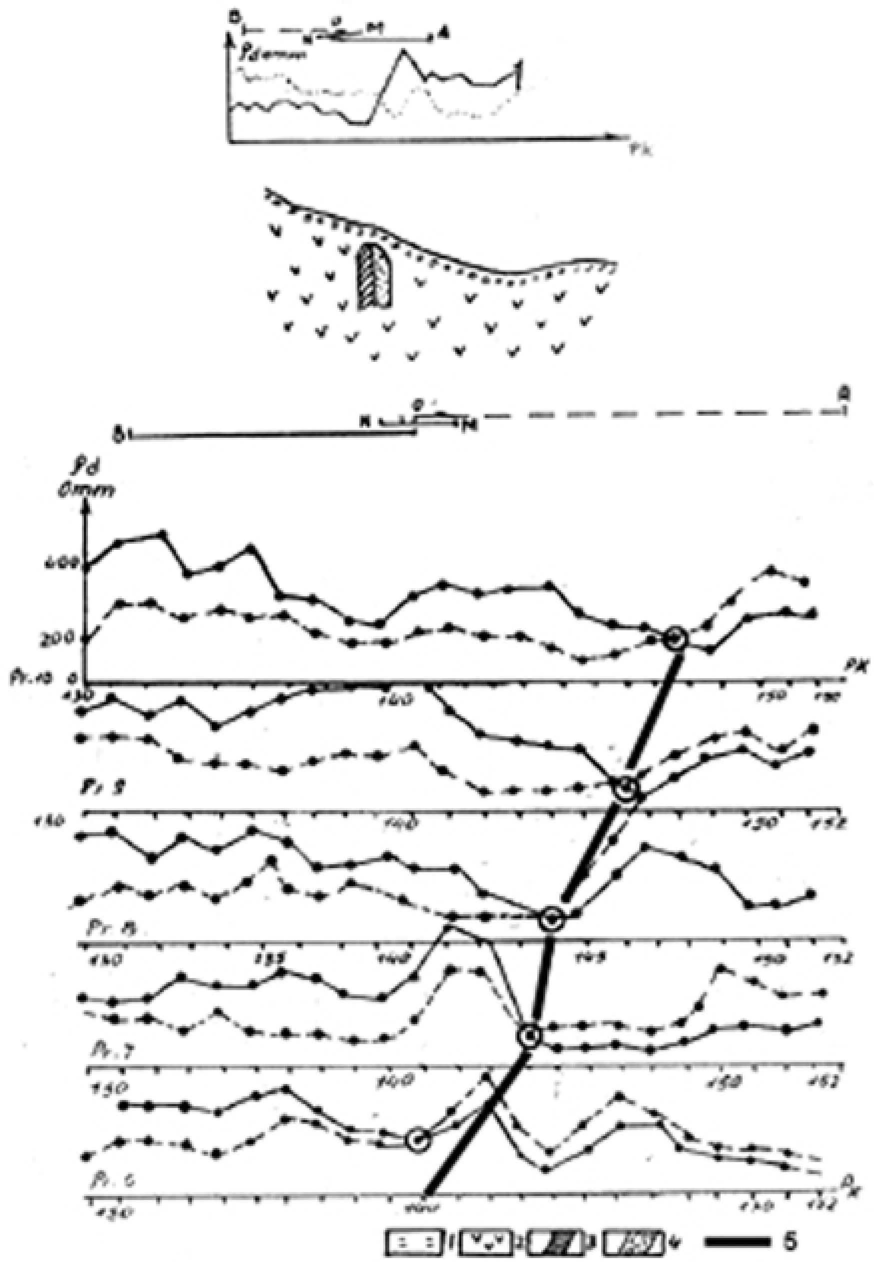

Fig. 2. Apparent Resistivity map and geoelectrical section in the Kaçinari massive sulphide deposit (After Daja E. and Avxhiu R.).
1- Overburden; 2- Diabase; 3- Massive ore body; 4- Disseminated ore sulphides; 5- Electrical conductivity axe.

In this period the depth of investigation increased to 200 m. Based on interpretation results of integrated geophysical-geochemical and geological data, Avxhiu R. etc. have discovered massive sulphide cooper deposit at Qafa Barit area (Fig. 3) (Avxhiu 1979).

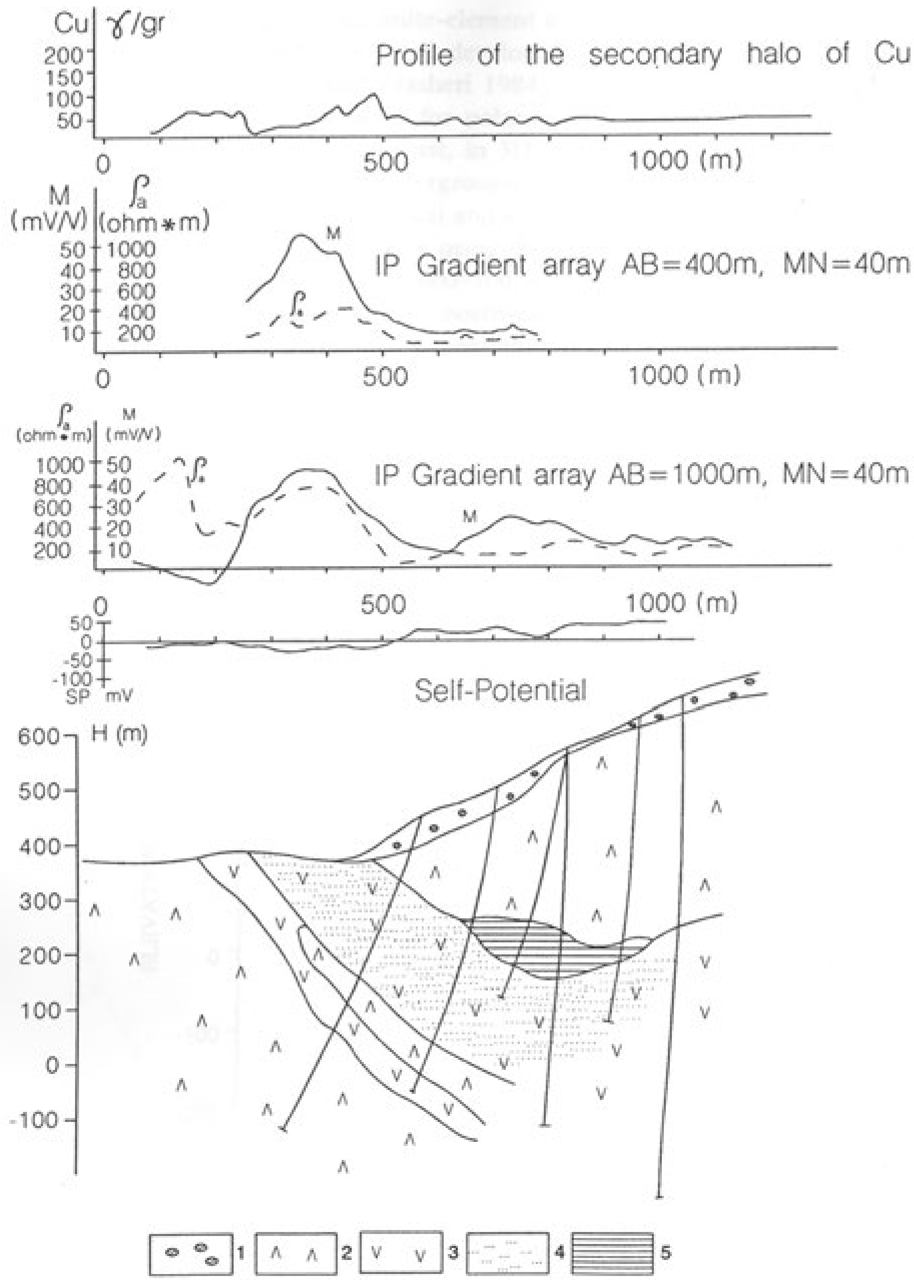

Fig. 3. Geological-geophysical section in the Qafa Barit massive sulphide deposit (Compiled after Avxhiu R. and Frasheri A data).

1- Overburden; 2- Keratophyre rock; 3- Spilites; 4- Disseminated sulphides; 5- Massive sulphide ore body.

Prospecting by the vertical geoelectrical sections, using “Real Section” as experimental method from 1978 year has been developed a new exploration strategy by Alikaj P (Alikaj P. and Morrison D. 1997, Alikaj P. 1998, Langiora Ll. and Alikaj P. 1989). Geoelectrical mapping by standard technology present a research in one of depth investigation over all surveys area. “Real section” method has creates the possibilities to realize a vertical exploration, from Earth surface up to the depth in surveys line, according to the used current electrode spacing.

3.1.2. Heavy, rare marine placers and river gold placers exploration.

Shallow Schlumberger vertical soundings and profiling have been used for solving of the different geological task: For littoral marine placers, search, mapping and shape determination of the sand dunes has been exploration objects. Mapping of the gravel riverbeds and morphology of riverbed base has been objects during the river gold placers prospecting. Geoelectrical markers in the littoral areas are top and base of sand dunes, among the Quaternary clay.

3.2. Marine resistivity surveys

Marine electrical soundings and profiling have been a part of integrated marine geological-geophysical for oil and gas exploration, along Albanian Adriatic Shelf, from Vlora Bay at the south to Shengjini Bay at the north (Frasheri A. 1987, Leci V. 19>>>>>.). Surveys lines have been extended within a distance of 10 km from the coastline, where the sea depth reaches about 50 m. Averagely sea depth was 10-20 m. in this marine space. Maximal current electrode spacing for the sounding arrays has been up to 16km, and for the profiling 100-400m.

The Durresi structure exploration represents a successfully example of integrtaed marine geological-seismic, resistivity soundings and profiling application. Based on this exploration have been drilled a deep well Du-16 which has been discovered a gas deposit; under the Adriatic Sea water structure (Fig. 4,5).

Durrës – Kepi Pallës area is characterized by a presence of Neogene’s molasses formation: Tortonian clay-sandstone, Messinian clay, sandstone interbeds and lens, and gypsum debris and blocks stage and Pliocene clay deposits. Up to present, by deep wells, is known that 2975-3125 m is thickness of Neogene molasses. Marine Quaternary loose deposits have covered bedrocks of the neogene molasses. These deposits are extended in the shallow offshore in Durresi-Kepi Palles area, and are presented by loose sand in the coastal line and clay mud far from coastline. Marine deposit thickness in the offshore are is 10 m near of the coastline in the Kepi Palles sector, which increased up to 20-50 m at the west.

Durrës-Kepi Pallës anticline is asymmetric and structure top is extended about 1600 m at the west of the coastal line, under the Adriatic Sea waters (Fig. 4,5). After Pliocene field extension, about 40 km is length of the structure, and 2 km width. The anticline amplitude is varies of 2000 up to 2500 m. Eastern flank is tectonically abrupt. Part of eastern limb of the structure has a dipping 45-55^o in the western location from tectonic line. At the depth, the dipping gradually is increased to 75-80^o up to overturned. At the surface, the tectonic line is outcropped at Kepi Pallës on shore. The tectonic line is located under Adriatic Sea waters toward the Porto Romano sector.

Tortonian sandstone packs of the eastern anticline flank, covered by marine Quaternary loose deposits, are mapped by electrical profiling (Fig. 5).

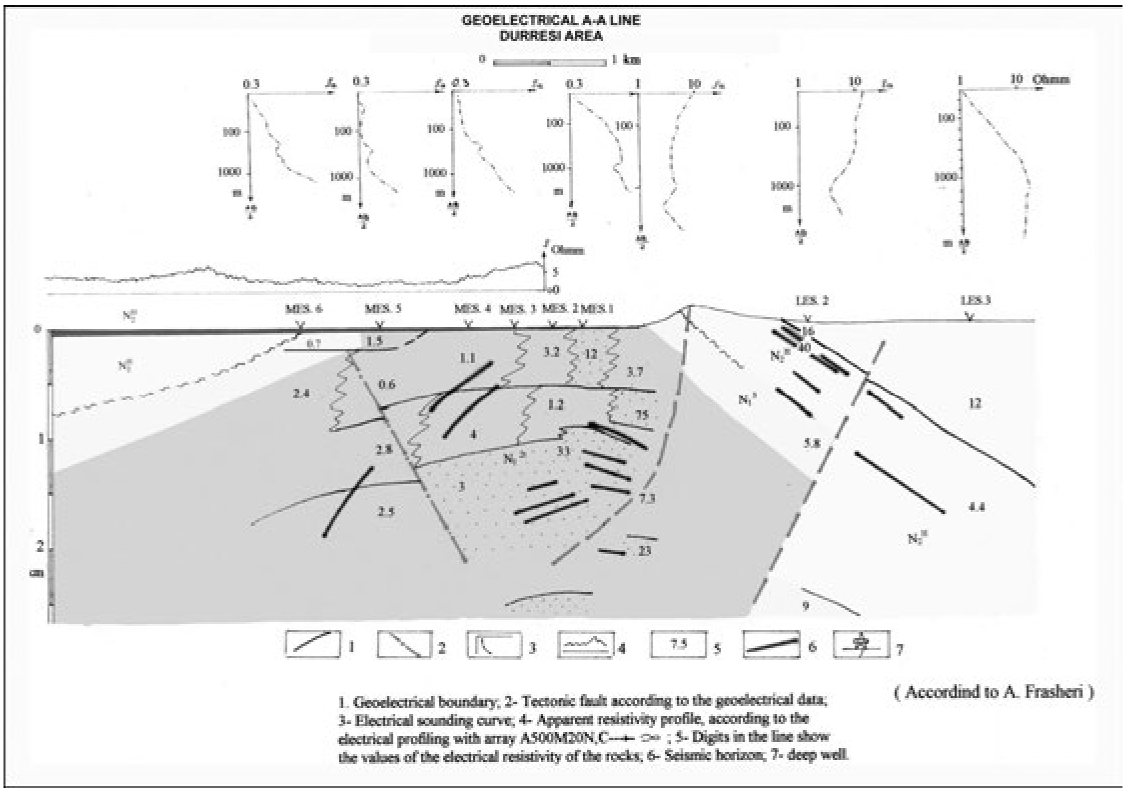

Fig. 4. Geological-geophysical profile, Durresi gas bearing structure.

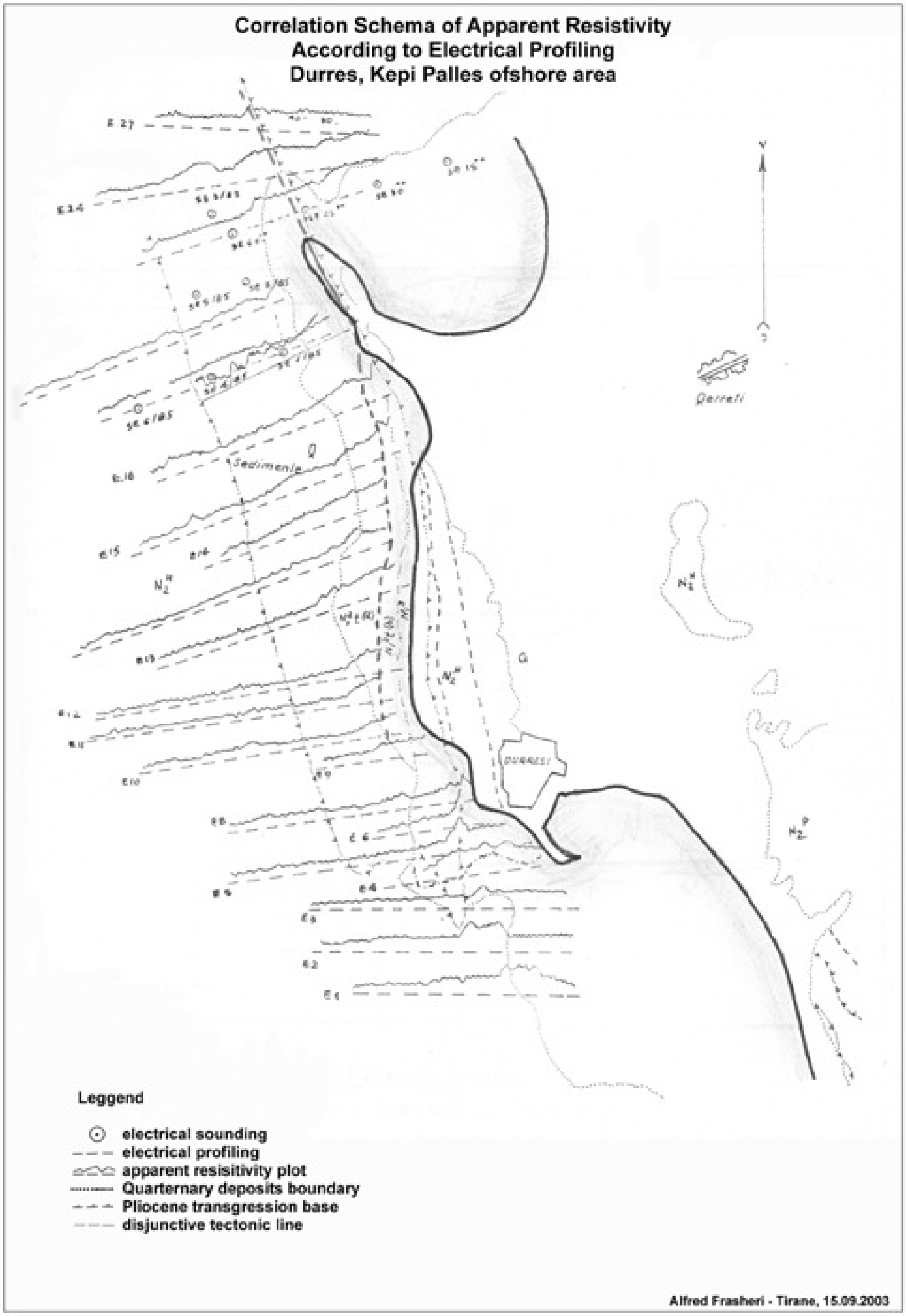

Fig. 5. Geoelectrical marine mapping of offshore eastern flank of Durresi anticline.

3.3. On shore oil and as exploration

On shore Schlumberger electrical soundings have been used for lithological identification of seismic reflectors from carbonate anticline top covered by terrigenoeus formations (flysch and molasses), for the sandstone packs estimation of the Neogene's molasses structures mapping, and salt diapir contact mapping in some reagions (Frasheri et al. 1982). Maximal current electrode spacing has been 16 km, consequently electrical soundings have a depth of investigation about 2000m and depth of the influence more than 4500m.

3.4. Geoelectrical mapping

Geoelectrical mapping of the contacts between different kind of the rocks, and of the tectonic faults, has been realized using multiple Schlumberger $A_1A_2A_3MNB_3B_2B_1$, with maximal electrode spacing A_1B_1=300m. Most effective has been mapping of the tectonic contact between Upper Triassic limestone and Lower-Middle Triassic Volcanic-Sedimentary pack, which is covered by diluvium.

3.5. Engineering investigations

3.5.1. Construction areas of industrial buildings and works, public and private buildings Traces of the highways, railways, tunnels and main irrigation channels (Frasheri et al. 1995).

3.5.2. Raw materials dams Geoelectric tomography was used to investigate the clay core of the dam's raw materials. The resistivity part of geoelectric tomography use multiple gradient arrays with the maximal current electrode spacing 300m, which provided a survey depth of 50-70m (Frasheri et al. 1995, 1992). The geoelectric tomography results in this paper are from Vau Dejes hydroelectric plant. Its Qyrsaqi dam has a concrete section and a gravel fill with central clay core section. The dam has a crest length of 480m and maximum height of 79m. Geoelectric tomography was performed only in the raw-material section.

The soil dam in Qyrsaqi is studied at the top of clay core and at its slope. Fig.6 shows a electrical resistivity tomography along the dam axe. It is noticed at the centre, that the clay material has a lower resistivity than the two dam's edges. The water filtering into the core explains this phenomenon.

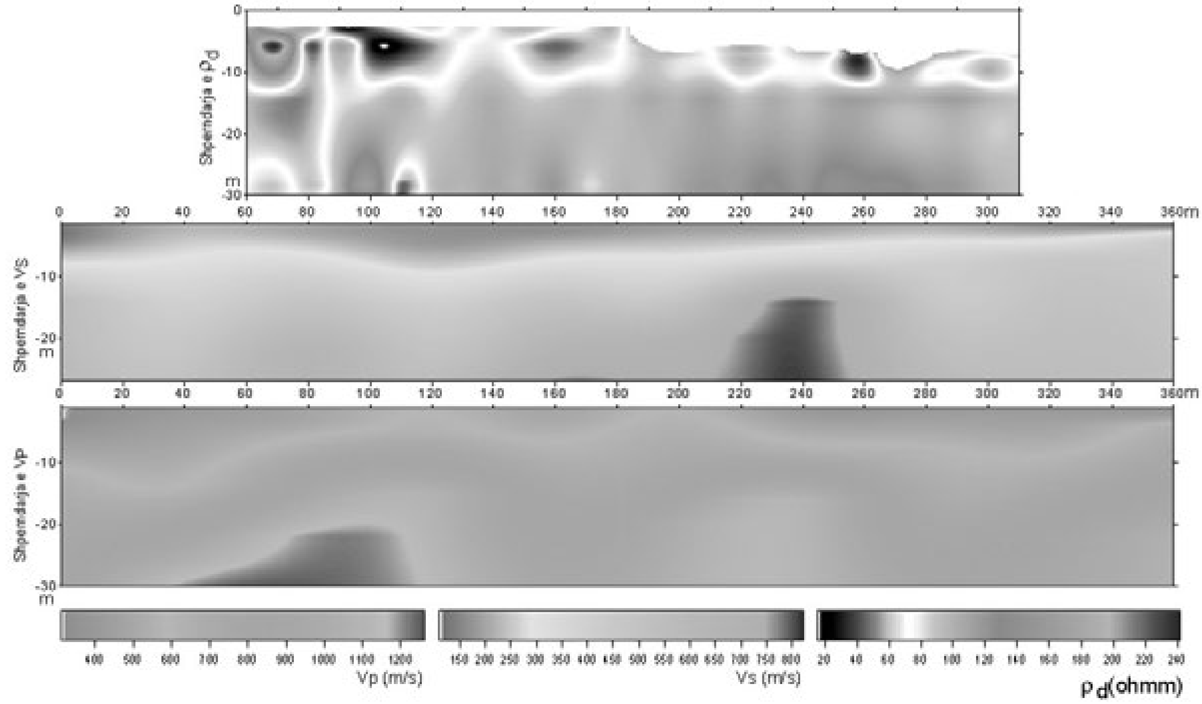

Fig. 6. Electrical Resistivity and seismic 2D Tomography, Qyrsaqi Hydropower Plant, Raw Material Dam

3.5.3. Slope stability and Landslide Investigation

Albania represents a mountainous country with complicated geology. There are unstable mountain and hill's slopes. Developing of new landslides or re-activation of the old ones is mainly due to construction works.

Landslides are located in the deluvial deposits, and in the altered-bedrock. The slipping bodies of some landslides have very big volume, more 50 million cubic meters.

Slope stabilization and landslides investigations have been realized successfully by integrated geophysical methods, which electrical soundings present an important method (Frasheri et al. 1985, 1997).**Porava landslide** is located in the lakeshore of the Fierza hydropower plant lake. Two geoelectrical markers are determined configuration of the sliding structure in the rocks of the volcanic sedimentary section.

Slope stabilization and landslides investigations have been realized successfully by integrated geophysical methods, which electrical soundings present an important method (Fig. 7).

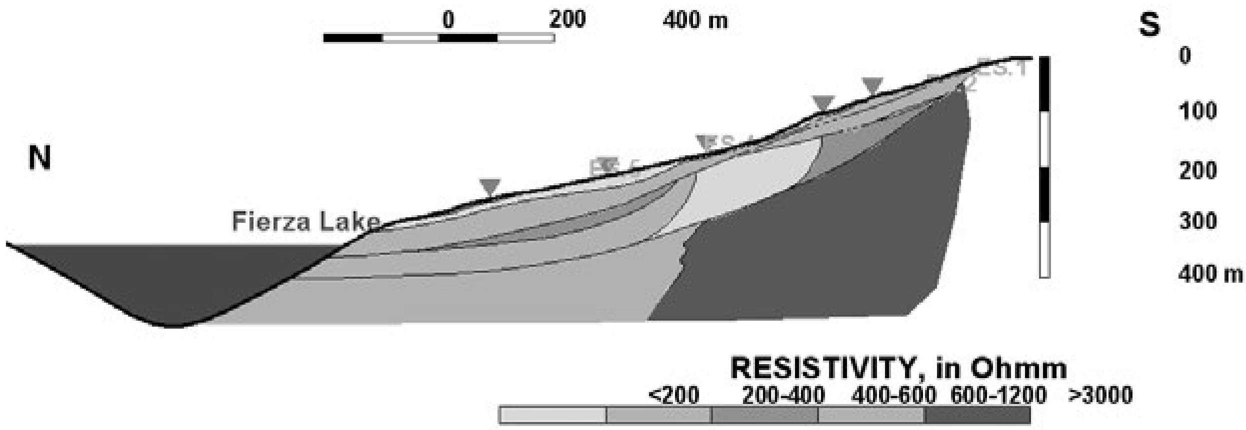

Fig. 7. Geoelectrical section and views of Porava landslide.

Section shows presence of two categories of geoelectrical markers in the profile, which are determined full configuration of the sliding structure in the rocks of the volcanic sedimentary section. The primary category belongs to the lower contact, at 140-160 m depth and the upper at 20 m depth, which separated rocks with different electrical properties. The lower boundary is the major boundary, which separated the slipping body from the main sedimentary-volcanic rocks. It is the geoelectrical marker that clearly envisages the bottom of the slipping body. As a result of the slipping phenomenon, these rocks have low up to medium electrical resistivity value (200-100 Ohmm). While the rock located under the whole massive slipping body have higher electrical resistivity values (in the farthest sector of the profile in the lake side 3000-3800 Ohmm and 1200-1400 Ohmm in the sector located near the artificial lake of Fierza hydropower plant). The upper boundary separated the slipping body into two big layers. The most upper part of this slipping body represented by the diluvium- eluvium deposits, is very active today and has very low resistivity values (120-500 Ohmm). This part is in continuous intensive movement, causing big damages for the houses of Porava village. The second category of boundaries is linked to the changes at heterogeneity in falling of slipping body, which is separated into blocks.

Considering the so far results of integrated geophysical-geotechnical investigations for Porava landslide, we realize that the Porava slipping body will not happen the immediate fall and at the same speed as the whole mass, because it is separated into blocks and cab fall in parts. The answer to this question is certain only after the slipping dynamic is studied and monitoring, when the question for slipping body’s progress during strong earthquakes.

3.5.4. Investigation of the ground degradation Kruja Castle Area

The Castle of Kruja is the symbol of Albanian culture and history. In 1995 the Castle was “shaken up” under the Museum Gjergj Kastrioti Skenderbeg which was considered a safe. This downfall occurred after a period of heavy rainfall, characterized by heavy showers and a rapid decrease of temperature. The

overnight failing down of the large detached masses of about hundreds of cubic meters was unexpected. The ground has started to deteriorate and at the sides in some places is developing a process of collapse .

By means of the geotechnical-geophysical investigation, it will be possible to provide a complete structural knowledge of the massifs either rock or half rock or soils. At the same time the characteristics and properties of the formation together with their dynamics can be provided through integrated in-situ tests: engineering geotechnical, geological and geophysical surveys: Refraction seismic of high frequency surveys, electrical soundings, recording of natural seismic micronoises, in situ parametric geophysical measurements on natural denudations and laboratory investigations of the rock samples. These data are necessary for determining technical solution for the emergency and future situation. The electrical soundings were carried out according to the Schlumberger array, with spacing $AB/2_{max}$ = 100 m.

3.6. Karstic zones and cave investigation

The karstified zones can be distinguished from the compact limestone by using the resistivity soundings carried out with Schlumberger array and by electrical profiling with multiple Schlumberger array $A_1A_2A_3MNB_3B_2B_1$ (Frasheri et al. 1982). In the karstified zones, the geoelectrical section is KH type. Depending on the thickness of layers, A type geoelectrical section is also possible. Karstified surface forms, which are filled with residues of the altered material has a resistivity of first layer is smaller than that of the second layer, represented by karstified limestones with empty lattices. The third geoelectrical layer shows the resistivity is lower that of the second layer. This is because the less dense karst lattice is filled with water or clay. The fourth geoelectrical layer is represented by compact limestone, and consequently its resistivity is higher than that of all overlying layers. Geophysical surveys have been realized by using detailed mapping scales 1:500 and even 1:200 with survey grid (1-2)x(2-5) meters.

Conclusions

Fifty years of a period of intensive resistivity method application in Albania, for solving of wide spectre of geological tasks, have demonstrated: 1) Resistivity method successfully has stood the time test, for more of a half a century. Resistivity method represents an important method in the applied geophysical exploration.

2) Applied with a numerous arrays, resistivity method successfully has solved many geological tasks for oil and gas exploration, mining hydrogeological prospecting, and engineering and environmental geophysics.

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The gratitude goes to the plead of the scientist that have paved the long and right way for the resistivity method: brothers Schlumberger (France), H. Lundberg (Sweden), O. Gish (USA), S. Stefanescu (Rumania), Wenner (Germany), A.I. Zabarovsky, V.N. Dahnov and A.P. Krayev (Russia) etc. and so many geophysicist engineers, which have developed the resistivity method.

I appreciate so much the contribution of my Albanian colleagues, geophysicists Docent Ligor Lubonja, Prof. Dr. Radium Avxhiu, Prof. Dr. Përparim Alikaj, mathematics Prof. Dr Neki Frasheri and Prof. Dr. Gudar Beqiraj, and Russian engineers V.M. Pigrov and S.A. Pogrebinskiy, for developing the resistivity surveys in Albania.

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GEOTHERMAL REGIME AND HYDROCARBON GENERATION IN THE ALBANIDES

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Abstract

The geothermal regime of the Albanides is described in this paper. Following a summary of the geological structure of the Albanides and of the oil and gas reservoirs in Albania, the parameters controlling the distribution of the present-day geothermal field are analyzed in detail: temperatures, geothermal gradient, heat flow density in the centre of Albanian Sedimentary Basin. The palaeo-thermal regime of the External Albanides is analyzed for the Upper Triassic-Eocene carbonates and the Middle–Upper Miocene and Pliocene molasse. The burial and thermal history of the External Albanides and the implications for hydrocarbon generation are analyzed.

Key words: Geothermal history, geothermal gradient, palaeo-geothermal regime, hydrcarbon generation.

1. Introduction

Geothermal studies have been carried out in Albania over the past 90 years, in the framework of Geothermal Atlas of Albania, the European Geothermal Atlas and the Atlas of the Geothermal Resources in Europe.

These studies were based on the temperature logs in the 137 deep oil and gas wells and in 50 shallow boreholes, and the following maps were prepared: Temperature Maps at 100, 500, 1000, 2000, 3000 metres depths, Average Geothermal Gradient Map, Heat Flow Density Map, and Geothermal Resources Thematic Map. Geothermal models have been developed, based on regional geological-geophysical profiles. Temperature distributions down to 50 km depth, based on these models have presented in two regional profiles: **Albanid-1** and **Albanid–2**, which run from Falco (Italian Adriatic Shelf) to the NE and SE of Albania (far location, see Fig. 1). The results of these modelling studies have been used in the interpretation of the Heat Flow Density Map of Albania. Thermal water springs and deep wells have been investigated, and geothermal potential of the reservoirs has been evaluated.

2. Geological setting of the Albanides

The Albanides represents the assemblage of the geological structures in the territory of Albania and, together with the Dinarides to the north and, the Hellenides to the south form the southern branch of the Mediterranean Alpine Belt. The Albanides are formed by two major palaeogeographic domains: the Internal Albanides in the eastern part and the External Albanides in the western part of Albania. The Internal Albanides are characterized by the presence of the immense and intensively tectonised ophiolitic belt, which is displaced from east to west as an overthrust nappe (Frashëri et al. 1996). The External Albanides developed on the western passive margin and continental shelf of the Adriatic plate. The External Albanides are affected only by the later palaeotectonic stages, and are characterized by regular overthrust structural belts. Geological and geophysical regional studies, based on facial-structural criteria, have distinguished a number tectonic zones (Fig. 1):

Internal Albanides: Korabi, Mirdita, and Gashi tectonic zones,

External Albanides Albanian Alps, Krasta-Cukali, Kruja, Ionian, and Sazani tectonic zones, and Peri Adriatic Depression.

Oil pools and gas reservoirs are located in the Ionian and Peri Adriatic Depression (Foto et al. 1998, Foto 2000, Misha et al. 1999).

The Ionian zone (Io) occurs the southwestern part of Albania and developed in a deep pelagic environment the upper Triassic. The Permian- Triassic evaporites are the oldest rocks in this zone. Overlying are thick deposits formed by Upper Triassic- lower Jurassic dolomitic limestones and Jurassic-Cretaceous-Palaeogene pelagic cherty limestones. The limestones are overlain by Palaeogenic flysch, an Aquitanian flyschoidal formation and a thin section of Burdigalian-Langhian (and partially of Serravalian-Tortonian), age which mainly fill the synclinal belts. The Burdigalian deposits unconformably overlay the anticline belts. Three tectonic blocks, representing the structural belts, are present in the Ionian zone:

a) The Berati anticline belt, in the eastern margin of the zone.

b) Kurveleshi anticline belt, in the central part of the zone.

c) Çika anticline belt, which represents the western edge of the Ionian zone.

Structures are fractured by longitudinal tectonic faults on their western flanks, with thrusting of 5-10 km horizontal displacement. Two main tectonic styles are distinguished in the Ionian zone: duplex tectonic and imbricate tectonic styles. Regional reflection seismic lines through the Ionian zone clearly show that during the overthrusting structuration of the Ionian zone, formations from upper Oligocene to Langhian were extended over underlying limestones of southern Adriatic basin and Sazani Zone.

Peri-Adriatic Depression. The overlying Peri-Adriatic Depression covers the Ionian, Sazani and part of the Kruja tectonic zones. This is a foredeep filled with middle Miocene and Pliocene molasse, which are mainly covered by Quaternary deposits. From south-east to north-west, the thickness of the molasse increases, reaching 5000 m. Serravalian and

Tortonian sandstone-clay deposits were trangressively extended over the older units, including the Eocene limestone.

The Albanian sedimentary basin extends in the Adriatic shelf with detrial and carbonate formations.

3. Oil pools and gas reservoir in Albania

There are 11 main oil and gas reservoirs are located in the Ionian zone and in the Peri Adriatic Depression (Fig. 1). Reservoirs are formed by carbonates and by sandstones of the molasse formation (Çuri 1993, Misha et al. 1999, Sazhdanaku et al. 1999).

Oil pools in carbonate reservoirs are located in the Kurveleshi anticline belt of Ionian tectonic zone. There are three types of carbonate reservoirs: Upper Cretaceous- Palaeocene-Eocene; Jurassic- Palaeocene- Eocene; and one of Upper Triassic- Palaeogene. The traps are generally of anticline type, sometimes partly eroded and covered by flysch or Neogene Molasse.

Oil pools in sandstone reservoirs occur in the Tortonian-Messinian molasse section that transgressed over the older formations up to Palaeogene limestones in the Peri Adriatic Depression. The Tortonian- Messinian molasse comprises by marine shale, submarine fans, and deltaic coastal sand and shale interbeds with coastal, bay, lagoon and delta deposits forming the Tortonian- Messinian reservoirs. These reservoirs can be oil and gas-condensate-bearing, oil-gas-bearing and oil-bearing. The hydrocarbons have been generated at depth in the carbonates.

In the oil pools, different types of hydrocarbons are present: condensates, highly paraffinic oil, paraffinic oil and asphaltic resinous oils. In the Kurveleshi Belt fields, aromatic-intermediate oils unsaturated with gas, and aromatic bitumens with high sulfur content have filled the reservoirs. Paraffinic- naphthenic petroleum occur in the Çika Belt. The wet and very wet associated gases have a high content of H_2S and CO_2 and are very

acidic. Stable carbon Isotopic ratios ($\delta^{13}C$) range from 37.4 up to 52.3%, which suggests the presence of at least two petroleum generation phases.

The Peri Adriatic Depression is the main gas production play in Albania (Dulaj & Gjini 1997). Biogenic gas reservoirs are located in the Miocene-Pliocene molasses, in which comprise massive shales, prodelta clays and submarine fans. The trap types are stratigraphic, and structural-lithological, formed during the Pliocene and post Pliocene tectonism.

The Upper Triassic to the Upper Cretaceous carbonate of Ionian, Kruja and Krasta-Cukali tectonic zones contain several rich to very rich source-rock intervals. The main interval are (Çuri 1993, Dulaj & Basha 1998):

- Bituminous Upper Triassic dolomitic schist, with T.O.C about 4.96% and vitrinite reflectance Ro=0.7-0.87%.
- Bituminous clay-dolomitic schists at the Upper Triassic-Lower Jurassic boundary, very rich with T.O.C up to 29.1%, and vitrinite reflectance R0 reaching 0.65%.
- Bituminous schist of Cretaceous, with T.O.C= 1- 27.1 % and vitrinite reflectance Ro=0.41= 0.446%.

For the all sources rock levels, the concentrated kerogen is predominately of Type I, and the dispersed kerogen of Type II.

The dispersed kerogen type in the Miocene-Pliocene molasses is predominately Type III-a and Type III-b, and has generated gas. T.O.C. has a low value, below 0.4%, and the vitrinite reflectance Ro=0.3- 0.5% even below 6000 m.

The great thickness of the sedimentary series, the occurrence of good quality source-rocks at several stratigraphic levels, the suitable relationship between source-rocks and reservoir/seal pairs and the structuration of the External Albanides provide excellent conditions for entrapment and preservation of major hydrocarbon accumulations at shallow and at greater depths.

The migration phases of hydrocarbons were during the Burdigalian, Tortonian and Pliocene are distinguished.

4. Geothermy of the External Albanides

The temperature: The geothermal field in the External Albanides is characterized by a relatively low temperature (Fig. 2, 3, Tab.1) (Čermak, Krešl, Kučerova et al. 1996, Frashëri 1993, 2001, Frashëri et al. 1999). In the central part of the Peri-Adriatic Depression the temperature at 100 metres depth varies from 8 to 20°C and at 6.000 metres depth increases to 105,8°C. According to the geothermal modelling, the temperature is 262,3°C at a depth 18.000 m, where the top of the crystalline basement is predicted. The isotherms follow the structural configuration of the Albanides. The observed geothermal field, with relatively low temperatures, is characteristic of sedimentary basins with a great thickness of sediments.

The geothermal gradient: The External Albanides are characterized by low geothermal gradients. In the Peri-Adriatic Depression, the gradient varies from 1,61-2,13 °C/100m. According to the modelling results, the gradient decreases below 15 km to a maximum of 0,9 °C/100m. This change of the gradient coincides with the top of the Jurassic carbonate section. All structural and lithological variations in the Ionic zone and Peri-Adriatic Depression are reflected in the distribution of the geothermal field. The higher gradients occur in the anticlinal molasse structures in the centre of the Peri-Adriatic Depression, with the higher value of about 2,13 °C/100m in the Pliocene clay section in the centre of Peri-Adriatic Depression. Increasing sand content decreases the geothermal gradient and the gradient also decreases (by 10-29%) in the limestone core of anticlines in Ionic zone. The lowest values of 0,7-1,1 °C/100m are observed in the deep synclinal belts. Over-pressure in the molasse of the Albanian Sedimentary Basin also has a great influence on the values of geothermal gradient. Local variations of the temperature and the geothermal gradient are

observed in a small distances of 7-8 km. For example, at a depth of 3000m the temperature may vary up to 8-9°C over these distances. Even in a vertical direction, the geothermal gradient values can change from 1,05 to 1,75 ^{o}C/`00m.

The Heat Flow Density: Heat Flow Density of the Albanian Sedimentary Basin ranges 25,2-41,4 mW/m^2, which represent an HFU = 0,60-0,98 (Fig.4, Tab. 1). Heat flow density has its highest value of 42 mW.m^{-2} in the centre of Peri-Adriatic Depression. The 30 mW^{-2} value isotherms open towards the Adriatic Sea Shelf.

In Table 2 the thermal regime of the oil pools and gas reservoirs in Albania are summarized.

The Palaeotemperature regime: The parameters of the present-day geothermal regime, seismic data, amount of removed sediments, tectonic subsidence analysis and geodynamics considerations have been used to calculate the palaeo geothermal model. This model was calibrated by measured vitrinite reflectance. Palaeotemperatures were estimated using Nemchenco N. methode (Nemchenco 2002).

The burial and thermal history of the of Upper Triassic- Jurassic-Cretaceous-Palaeocene and Eocene carbonate section, the Lowe Oligocene flysch section, and Middle-Upper Miocene and Pliocene molasse is presented in Table 3 in particular the thermal regime for the main carbonate source rocks, with kerogen of Type I concentrated and Type II dispersed kerogen.

Modelling results indicate that maximum temperatures of 105,3 ^{o}C occurred during Upper Triassic-Lower Oligocene with palaeogeothermal gradient ranges of 1,28-2,10 ^{o}C/100 meters and a heat flow density of 38,5 mW/m^2. Maximum temperature in the main Cretaous carbonate source rocks was 54,5 ^{o}C. In these conditions, the organic matter would have been thermally mature, entering the oil window. The Upper Triassic to Lower Oligocene section of the Albanian Sedimentary Basin would thus entered the first phase of the hydrocarbon generation, with condensate, oil and gas. Later, during the Middle-Upper Oligocene and

Miocene, the carbonate section was located at greater depth, with maximum temperatures up to 250°C. This geothermal regime created the thermal conditions for methane generation, thus consideration opening up new possibilities for the discovering of methane reservoirs at the depth of the Albanian Sedimentary Basin.

Maximum temperatures up to 122,8°C, with a geothermal gradient 1,67 °C/100 m and Heat Flow Density ranges of 39,8-41,2 mW/m^2 during the Middle and Upper Miocene, created the thermal conditions for maturation of the organic material in the molasse formations, and also in the Pliocene section, where the maximum temperature is 64,9°C, geothermal gradient up to 2,13 °C/100 m, and Heat Flow Density 41,4 mW/m^2. However, the general interpretation of the Albanian petroleum geologists is that in molasse formations the gas was generated biogenically from Typr III organic matter. The oil of molasse section is correlated with the carbonate source rocks is thought to have migrated through the eroded tops of the limestone anticlines.

The thermal regime in the Middle-Upper Miocene, with the temperatures up to 122,8°C and Heat Flow Density 41,2 mW/m^2, creates the possibility that the complete molasses section was in the oil window and oil have been generated from organic material within it. This interpretation could open new possibilities for discovery oil pools in the Miocene molasses in suitable traps, which do not have direct contact with eroded limestone anticlines.

5. Conclusions

1. The Albanian Sedimentary Basin represents a major and deep geological structure with a relatively low Heat Flow Density at the present-day, equal with maximum 0.98 HFU. Temperatures range from 20.7°C at the top of the Pliocene section to 262,3°C, at the top of the crystalline basement. Geothermal gradients range between 0,9-2,13 °C/100 m.

2. During the sedimentation of the Upper Triassic-Eocene carbonate, the temperature ranged between 34,6-105,3^{o}C, and consequently the organic matter become thermally mature, and able to generate hydrocarbons. This was the first phase of hydrocarbon generation. With increasing of the basin subsidence, the temperature of the carbonates was raised to 250^{o}C, and with suitable conditions for methane generation. This represents the second phase of the hydrocarbon generation.

3. During the sedimentation of the Middle-Upper Miocene age, the molasse formations reached a temperature of 122,8^{o}C and a Heat Flow Density 41,2 mW/m^{2}, which has created the possibility for the molasses section to enter the oil window, and oil may have generated from organic matter. This interpretation could open new possibilities for discovery of oil pools in suitable traps in the Miocene molasses of the Albania Sedimentary Basin, onshore and offshore. The biogenic gas generation in the Middle-Upper Miocene and Pliocene molasse represents the third phase of the hydrocarbon generation in Albanides.

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LIST OF CAPTIONS

Tab. 1

Present – day geothermal regime of the Albanian Sedimentary Basin

Age	Temperature (^oC)	Geothermal Gradient ($^oC/100m$)	Heat Flow Density		Note
			(mW/m^2)	HFU	
Pliocene ($N_2^{Rrogozhina\ section}$)	20.7-37.1	1.61	41.4	0.98	After Ko-10 data
Pliocene ($N_2^{Helmesi\ section}$)	37.1-64.9	2.13	41.3	0.98	After Ko-10 data
Upper Miocene (N_1^3)	64.9-122.8	1.67	41.2	0.98	After Ko-10 and A-18 data
Middle Miocene (N_1^2)	122.8-143.7	1.61	39.8	0.95	After calculated data
Lower Miocene (N_1^1)	143.7-175.1	1.43	36.4	0.87	
Oligocene (Pg_3)	175.1-216.3	1.29	34.3	0.81	
Paleocene-Eocene (Pg_{1-2})	216.3-222.6	1.26	30.6	0.73	
Cretaceous (Cr)	222.6-235.1	1.14	23.7	0.56	
Jurassic (J)	235.1-247.8	0.98	24.6	0.59	
Upper Triasic (T_3)	247.8-256.8	0.90	25.2	0.60	
Lower-Middle Triasic (T_{1-2})	256.8-262.3	1.00	33.3	0.79	
Crystal Basement	262.3				

Table 2

Thermal regime of the oil pools and gas reservoirs in Albania

Reservoir		Thermal regime			Average depth (m)	Fluid
Lithology and age	Location	Temperature (°C)	Gradient (°C/100m)	Heat flow density (mW/m^2)		
Limestone Pg_{1-2}-T_3	Gorisht	37.0-55.0	1.86	48.0	1 300	Oil and gas
	Ballsh	28.4-49.4	1.59	41.0	1 500	
	Finiq	31.3-40.2	1.39	35.9	1 750	
	Amonica	42.8-54.6	1.53	39.5	2 450	
	Cakran	49.9-71.2	1.54	39.7	3 100	Condensate-Oil
	Delvina	30.8-41.3	1.17	30.2	3 100	
Sandstone Upper & Middle Miocene	Marinza	33.4-37.8	1.72	36.0	1 100	Oil and gas
	Kuçova	19.6-34.6	1.67	32.0	750	
Sandstone Upper Miocene	Divjaka	21.0-78.6	1.95	48.2	1 900	Mixed biogenic gas
Sandstone Pliocene	Ballaj	23.4-47.9	2.18	43.0	1 000	Very dry, biogenic gas

Table 3

Burial and thermal history in the Albanides- implication for hydrocarbon generation

Litho-logy and age	Palaeothermal regime				Buried rate m/Ma	Geochemical data			Hydrocarbon generation phase
	Tempe-rature, °C	Gradient °C/100m	Heat Flow Density mW/m^2	Tempe-rature rate °C/Ma		Kerogen type	Vitrinite reflectance Ro (%)	Geo-thermo metre (°C)	
Molasse Pliocene	28.83-48.57	1.85	41.8	3.96	350	III	<0.5	<50	IIIrd Biogenic Gas
Molasses Middle-Upper Miocene	48.57-70.70	1.8	45.6	2.59	300				
Carbonate Pg_{1-2}-T_3 And Flysch Pg_3^1	34.6-105.3	1.28-2.10	38.5	0.62	30	I and II	0.41-0.87	43-104	Ist Oil, condensate and gas, IInd Methane phase at temperatu-res higher than 200°C during the Neogene sedimenta-tion.
Main carbonate source rocks with kerogen Concentrated of Ist type and dispersed of IInd type									
Cr_2-Cr_1	54.5	1.82	37.9			I	0.41-0.446	43	
J_1-T_3	92.5	1.80	34.4			I	0.65	76	
T_3	97.8	1.50	28.6			I	0.7-0.87	85-104	

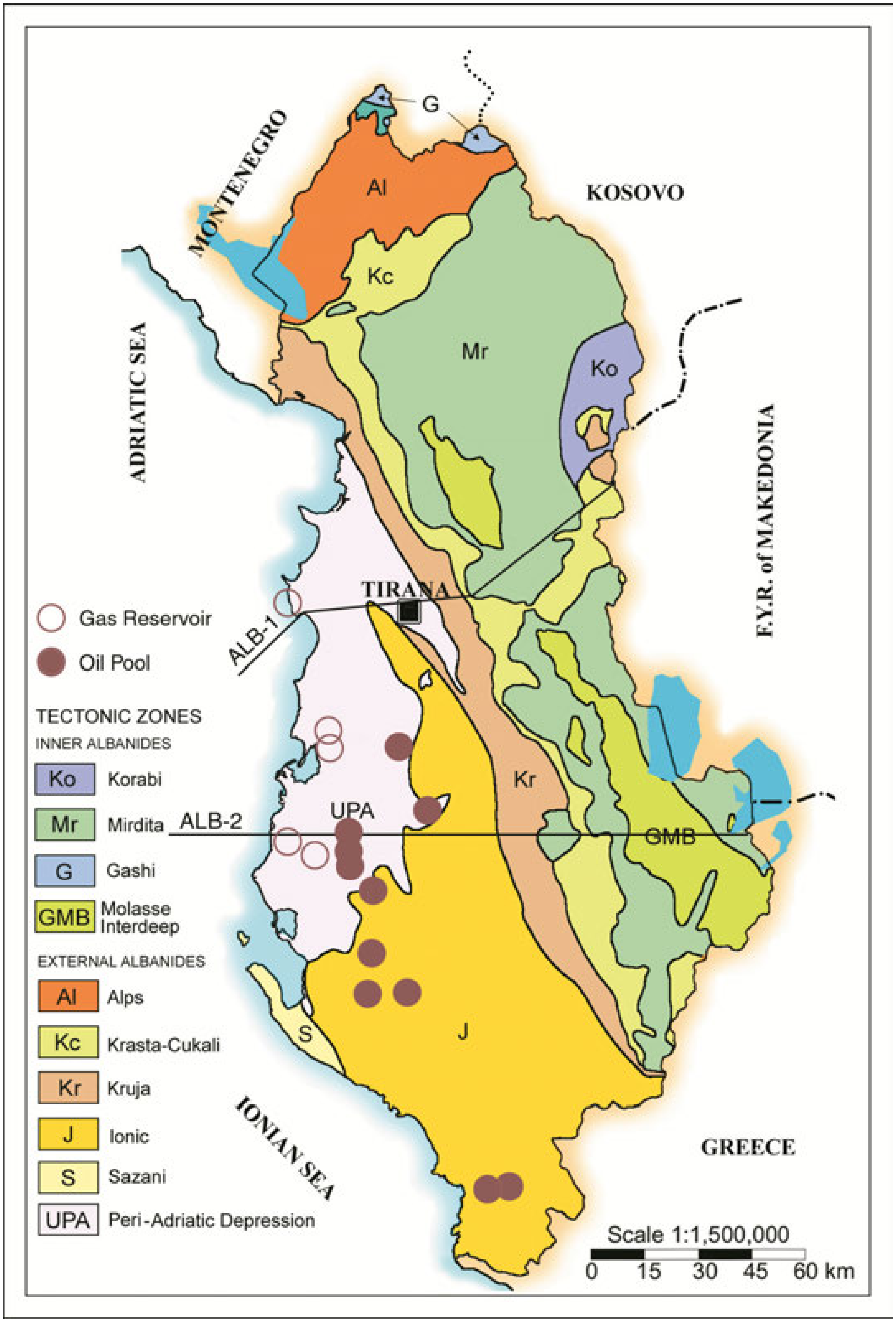

Fig. 1. Schematic Tectonic Map of Albania and oil and gas reservoirs

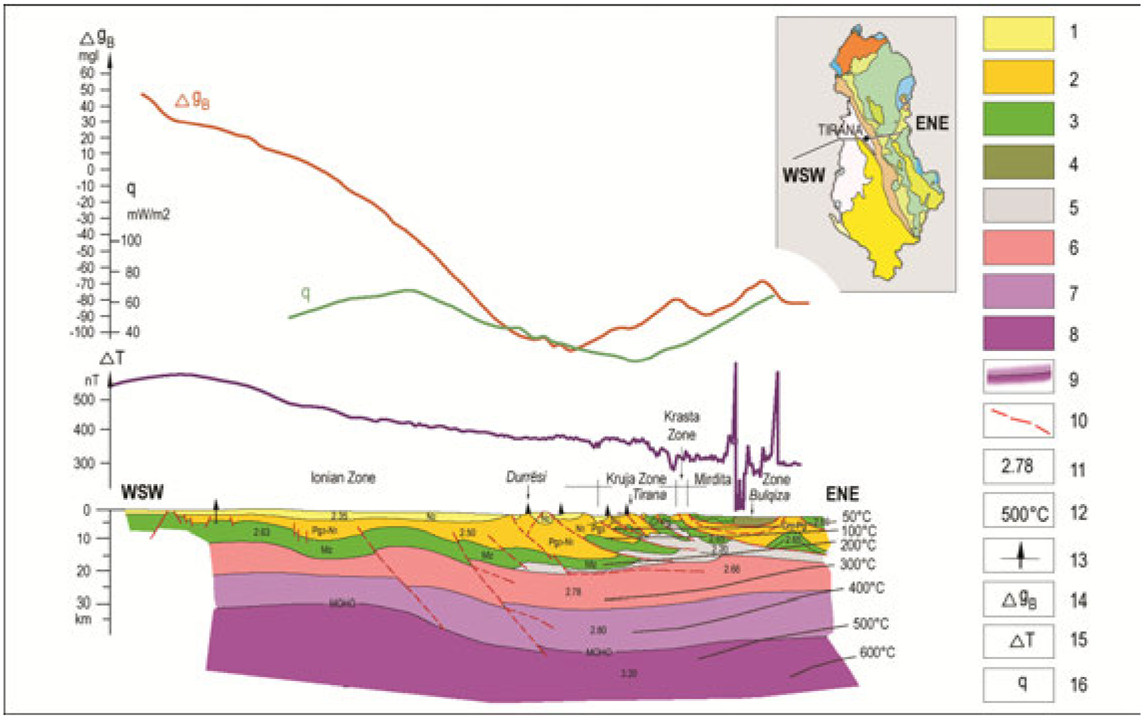

Fig. 2. Geological-geophysical regional profile of the Albanides (Adriatic Shelf-Durres-Tirana-Peshkopi).

1- Miocene -Pliocene Molasses; 2- Paleogene-Lower Neogene Flysch and Flyschoidal Formation; 3- Mesozoic-Eocene Carbonate Formation; 4- Ultrabasic Rocks; 5- Salt; 6- Upper Crust; 7- Lower Crust; 8- MOHO Discontinuity; 9- Overthrust tectonics; 10- Crustal Fractures; 11- Density; 12- Temperature; 13- Deep Wells; 14- Bouguer Anomaly; 15- Magnetic Anomaly; 16- Heat Flow Density.

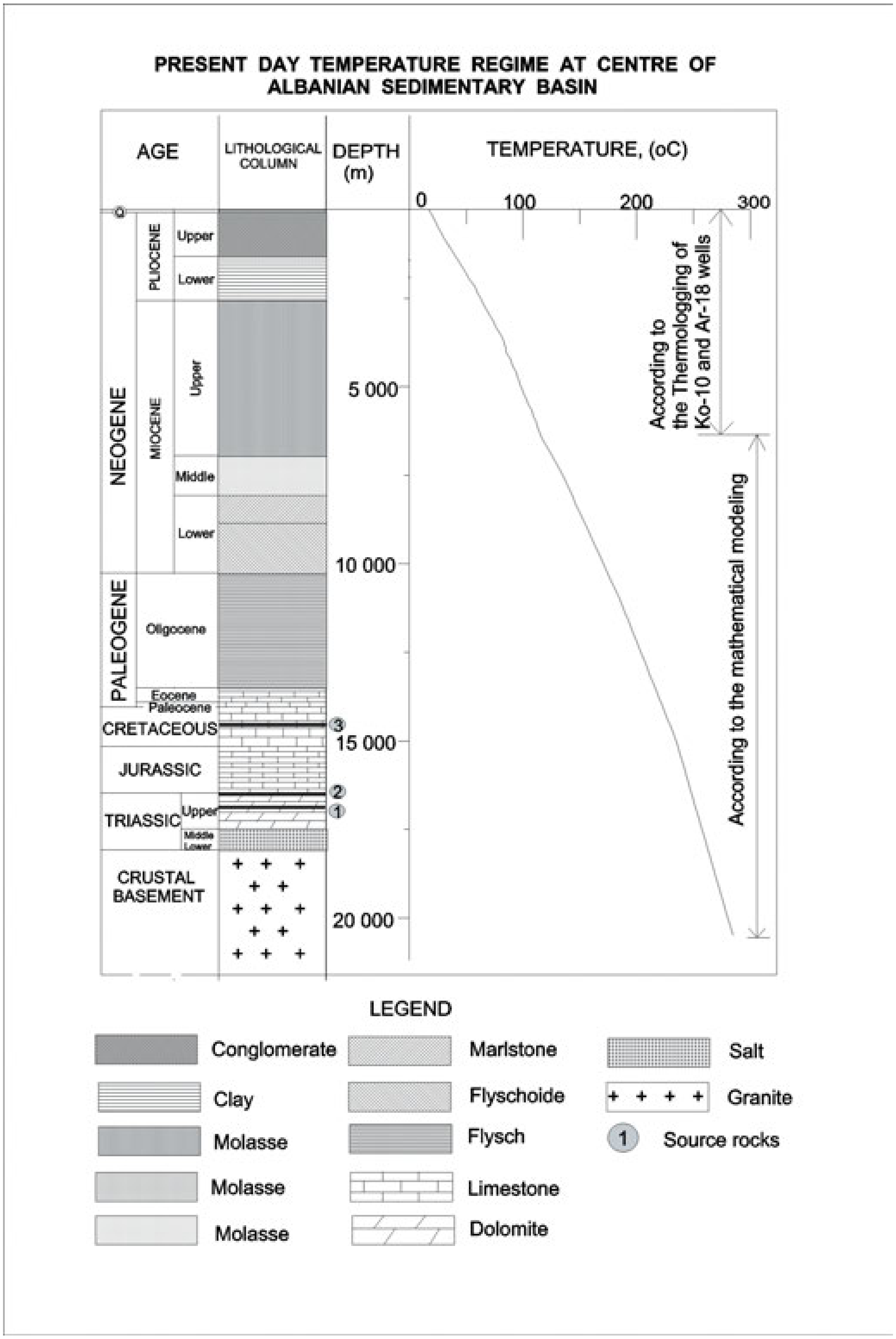

Fig. 3. Present-days temperature regime in the centre of the Albanian Sedimentary Basin.

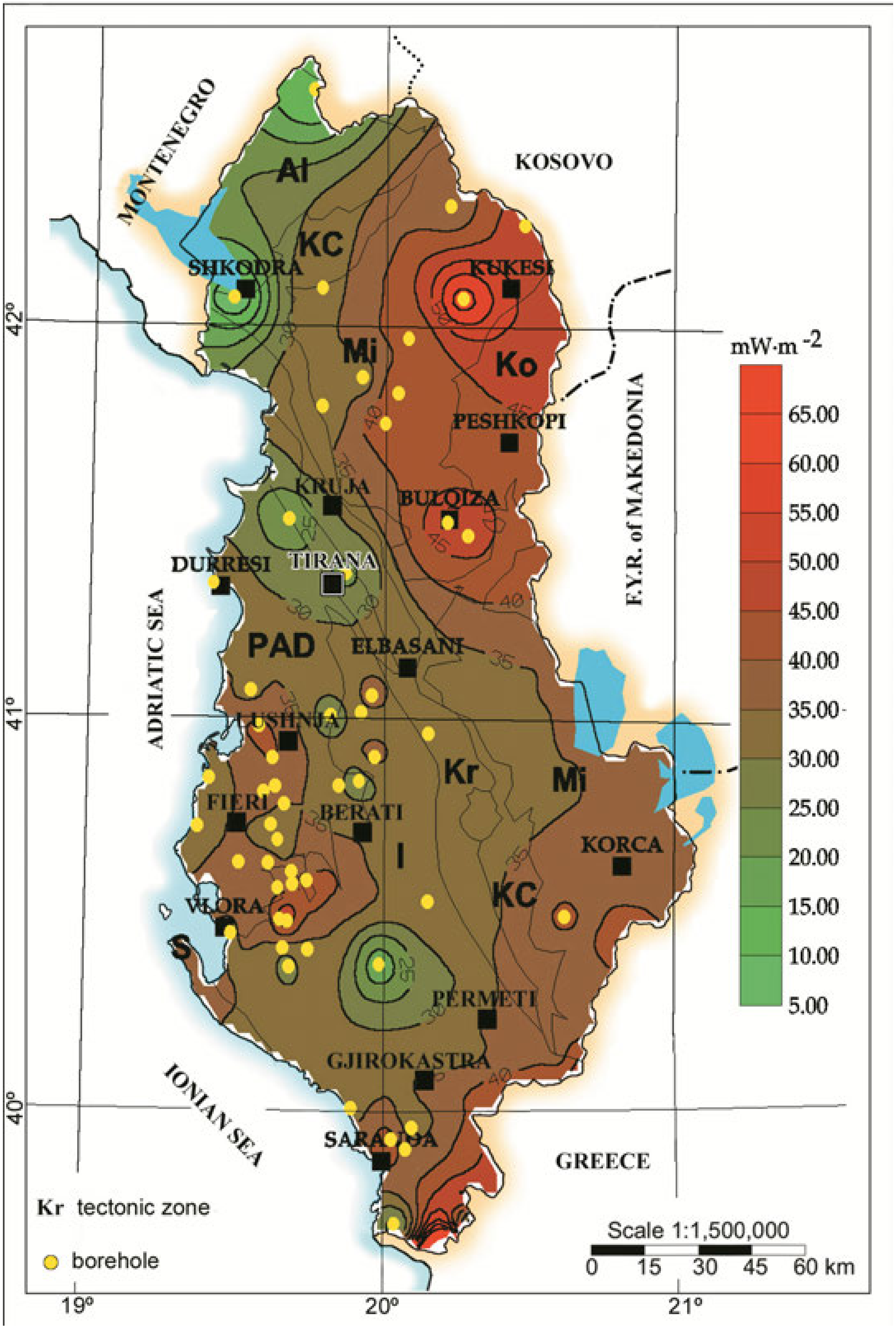

Fig. 4. Heat Density Map of Albania.

Geothermal Energy Resources in Albania - Country Update

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Keywords: Geothermal energy, direct use, heat flow,.

ABSTRACT

In this paper the geothermal region of Albanides and geothermal resources of Albania are presented. Shortly there are represented the methodic of geothermal studies and the evaluation of geothermal energy reserves. The fields of geothermal gradient are detailed and heat flow fields are represented. Particular attention is shown to the analysis of geothermal energy resources.

Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters are sulfate, sulfide, methane, and iodinate-bromide types. Thermal sources are located in three geothermal zones:

Kruja geothermal zone represents a zone in carbonate reservoirs.

Ardenica geothermal zone with sandstone reservoirs.

Peshkopia geothermal zone, is located with disjunctive tectonics of the gypsum diapir.

The geothermal situation in Albania offers three directions for the exploitation of geothermal energy:

1. The use of the ground heat flow for space heating and cooling, by borehole heat exchanger-heat pumps systems.

2. Thermal water sources and wells of low enthalpy. They represent the basis for a successful use of modern technologies for a complex and cascading utilization of this energy:

SPA clinics and hotels for eco-tourism.

Sanitary hot water for SPA and hotels, and hot waters for greenhouses and aquaculture installations.

Extraction of chemical microelements.

3. The use of deep abandoned oil and gas wells as "Vertical Earth Heat Probe".

Actually in Albania it is published the "Atlas of Geothermal Resources in Albania" (http://www.inima.al/~nfra/projects/geothermal/AlbanianGeothermalAtlas.pdf).

Sensitization brochure on "Use of environmental friendly geothermal energy" (supported by UNDP-GEF SGP) may be found at http://www.inima.al/~nfra/geothermal/ and also at http://www.Geothermie.de/.

1. INTRODUCTION

This paper represents a summary of the important results of the Monograph "Atlas of geothermal resources in Albania" 2004 The Monograph is prepared in the framework of the National Program for Research and Developing- Natural Resources, 2003-2005. This Atlas represents the publication of the results of studies which were performed in the framework of the Committee for Sciences and Technology of Albania Projects and agreement between the Faculty of Geology and Mining, and the Geophysical Institute, Czech Acad. Sci., Prague, European Commision- International Heat Flow Commission and UNDP-GEF/SGP Tirana Office projects [Frasheri A. 1992, Frasheri A. et al. 1994, 1995, 1996, 2001, 2003].

In Albania there are many thermal water springs and wells of low enthalpy, with a temperature of up to 65.5°C, which indicates that there are possibilities for direct use of the geothermal energy. In Albania the new technologies of direct use of geothermal energy are either partly developed or remain still untouched. Integrated and cascading use of geothermal energy of low enthalpy will represent an important direction for profitable investment. Utilization of geothermal energy will have a direct impact in the development of the regions, by increasing their per capita income and at the same time ameliorating the standard of living of the people.

2. GEOLOGY BEACKGROUND

The Albanides represent the main geological structures that lie on the territory of Albania. They are located between the Dinarides in the north and the Helenides in the south, and together they form the Dinaric Branch of Mediterranean Alpine Belt. Albanides are divided in two big peleogeographical zones: the Inner Albanides and the External Albanides. Korabi, Mirdita (ophiolitic belt), presents the Inner Albanides and Gashi zones. The Alps, the Krasta-Cukali, the Kruja, the Ionian zone, the Sazani zone and the Pre-Adriatic Depression represent the External Albanides. The Depression as a part of Albanian Sedimentary Basin, continues towards the shelf of the Adriatic Sea. The geological cross-section of Albanian Sedimentary Basin is about 15 km thick and it also continues into the Adriatic Sea Shelf.

The Ionian zone developed as a large pelagic trough in the Upper Triassic. There, the evaporites of the Permian-Triassic are overlapped by a thick carbonatic formation of the Upper Triassic-Eocene. The geological section on this carbonatic formation is covered by Oligocene flysch, a flyschoid formation of the Aquitanian and by schilieres of the Burdigalian, Helvetian and particularly of Serravalian-Tortonian molasse. Burdigalian deposits are overlapped transgressively with an angular unconformity, anticline belts. The Tortonian Age deposits have filled the synclinal belts of Ionic and Kruja tectonic zones.

Miocene and Pliocene molasse of Peri-Adriatic Depression overlies the structures of northern part of the Ionian zone. The structure of Neogenic molasses represents the upper tectonic stage of the structure of the Peri-Adriatic Depression.

In the over part of the section of Kruja zone, the carbonatic neritic rocks of the Cretaceous-Paleogene age are overlying the Oligocene flysch of a thickness of 5 km.

The structures of the Albanides are typically Alpine ones. The SSE-NNW directions represent their general strike. The structures are asymmetrical and have a western vengeance. Recumbent, overthrusted and overtwisted structures are also found. Generally, their western flanks are affected by disjunctive tectonic.

3. METHODS AND STUDY AREA

Geothermal studies carried out in Albania are oriented toward the study of the distribution of the geothermal field and the natural thermal water springs and wells. Geothermal studies were extended throughout the country territory.

The temperatures have been measured and the geothermal gradient and the heat flow density at different depths have also been calculated (Frasheri et al. 1995). Temperature measurements were carried out both in 145 deep wells, in boreholes and in mines, at different hypsometric levels. The temperature in the wells was recorded at regular intervals. It was measured by means of resistance and thermistor thermometers. The average absolute measurement error was 0.3°C. The measurements were carried out in a steady-state regime of the wells filled with mud or water. The recorded data was processed using the trend analysis of first and second degrees. The chemical composition of the waters was found. The output of the springs and wells and their hydrogeology was evaluated.

4. RESULTS

4.1.Geothermal Regime

The Geothermal Regime of the Albanides is conditioned by tectonics of the region, lithology of geological section, local thermal properties of the rocks and geological location (Frasheri A. 1992, Frasheri et al. 1994, 1995, 2004).

4.1.1. Temperature

The geothermal field is characterized by a relatively low value of temperature. The temperature at a depth of 100 meters, varies from less than 10 to almost 20°C, with the lowest values in the mountain regions. The temperature is 105.8°C at a depth of 6000 meters, in the central part of the Peri-Adriatic Depression. The isotherm runs parallel to the Albanides strike (Fig. 1). Going deeper and deeper the zones of highest the temperatures move from southeast to northwest, towards the center of the Peri-Adriatic Depression and even further towards the northwestern coast. The temperatures in the ophiolitic belt is higher than in sedimentary basin, at the same depth.

4.1.2. Geothermal Gradient

In the External Albanides the geothermal gradient is relatively higher. The geothermal gradient displays the highest value of about 21.3 mK.m-1 in the Pliocene clay section in the centre of Peri-Adriatic Depression. The largest gradients are detected in the anticline molasses structures of the center of Pre-Adriatic Depression (Fig. 5). The gradient decreases about 10-29% where the core of anticlines in Ionic zone contains limestone. The lowest values of 7-11 mK.m-1 of the gradient are observed in the deep synclinal belts of Ionic and Kruja tectonic zones (Fig.2).

In the ophiolitic belt of the Mirdita tectonic zone, the geothermal gradient values increase up to 36 mK.m-1 at northeastern and southeastern part of the Albania.

4.1.3. Heat Flow Density:

Regional patterns of heat flow density in Albanian territory are presented in the Heat Flow Map. There are observed, two particularities of the scattering of the thermal field in Albanides (Fig. 3):

Firstly, maximal value of the heat flow is equal to 42 mW/m2 in the center of Peri-Adriatic Depression of External Albanides. The 30 mW-2 value isotherm is open towards the Adriatic Sea Shelf. These phenomena have taken place owing to the great thickness of sedimentary crust, mainly carbonatic one in this zone.

Secondly, in the ophiolitic belt at eastern part of Albania, the heat flow density values are up to 60 mW/m2. The contours of Heat Flow Density give a clear configuration of the ophiolitic belt. Radiogene heat generation of the ophiolites is very low. In these conditions, increasing of the heat flow in the ophiolitic belt, is linked with heat flow transmitting from the depth. The granites of the crystalline basement, with the radiogenic heat generation, represent the heat source.

4.2. Geothermal energy resources in Albania

Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters with a temperatures that reach values of up to 65.5°C are sulfate, sulfide, methane, and iodinate-bromide types (Frasheri A. et al. 1996, 2004) (Tab. 1, Fig.4). In many deep oil and gas wells there are thermal water fountain outputs with a temperature that varies from 32 to 65.5°C (table 2, Fig. 3)

Albanian geothermal areas have different geologic and thermo-hydrogeological features. Thermal sources are located in three geothermal zones (fig. 4):

Kruja geothermal zone represents a zone with bigness geothermal resources. Kruja zone has a length of 180 km. Kruja geothermal zone is extended from the Adriatic Sea in the North and continues to the South-Eastern area of Albania and into the Konitza area in Greece. Photo 1 shows Langarica - Permet thermal springs in southern Albania. Identified resources in carbonate reservoirs in the Albanian side are 5.9x108-5.1x109 GJ. The most important resources, explored until now, are located in the Northern half of the Kruja Geothermal Area, from Llixha-Elbasan in the South to Ishmi, in the North of Tirana. The values of specific reserves vary between 38.5-39.63 GJ/m2.

The Kruja geothermal area represents an anticline structure chain with carbonatic core of Cretaceous-Eocene age. They are covered with Eocenic- Oligocenic flysch. Anticlinals are linear with lengths between 20-30 km. They are assymmetric and their western flanks are separated from disjunctive tectonics. Geothermal aquifers are represented by a karstified neritic carbonatic formation with numerous fissures and microfissures.

In the Ishmi area, the Ishmi 1-b well had been drilled in 1994. It is situated at the top part of the limestone structure. It is located 20 km North- West of Tirana, in the plain area, near “Mother Theresa” Tirana airport. It meets limestone at 1300m of depth and goes through a carbonatic coupe of 1016 m thickness.

Kozani 8 well had been drilled in 1989 (Photo 2). It is situated 35 km South- East of Tirana and 8 km North- West of Elbasani. It is situated on hills close to Tirana- Elbasani national road. It meets limestone at 1810m of depth and goes 10m deep in them.

Since the end of the drilling to this day hot water continues to fountain from Ishmi 1-b and Kozani 8 wells.

Elbasani Llixha watering place is about 12 km South of Elbasani. There are seven spring groups that extend like a belt with 320o azimuth. All of them are connected with the main regional disjunctive tectonics of Kruja zone. Thermal waters flow out through the contact of a conglomerate layer with calcolistolith. In this area too, the reservoir is represented by the Llixha limestone structure. The springs had been discovered before the Second World War.

Surface water temperatures in the Tirana-Elbasani zone varies from 60° to 65.5°. In the aquifer top in the well trunk of Kozani 8 the temperature is 80°C. Hot water is mineralized, with a general mineralization of 4.6-19.3 g/l. Elbasani Nosi Llixha water has the following formula:

$$H_2S_{0.403}M_{7.1}\frac{Cl_{59}SO_{38}^{4}}{Na_{46}Ca_{35}}$$

Peshkopia geothermal zone is situated in the Northeast of Albania. Two kilometers East of Peshkopia some thermal springs are situated very close to each other. These thermal springs flow out on the Banja river slope. These springs are linked with the disjunctive tectonic seismic-active zone Ohrid Lake-Debar, at periphery of gypsum diapir of Triassic age, that has penetrated Eocenic flysch, which surround it like a ring. The occurrence of thermal waters is connected with the low circulation zone always under water pressure. They are of sulfate-calcium type, with a mineralization of up to 4.4 g/l, containing 50 mg/l H2S. Their chemical formula is:

$$H_2S_{0.0495}M_{4.4}\frac{SO_{56}^{4}}{Ca_{65}}$$

The yield of some of the springs goes up to 14 l/sec. Water temperature is 43.5 °C.

The water temperature, high yield, stability, and aquifer temperature of Peshkopia Geothermal Area are similar with those of Kruja Geothermal Area. For this reason geothermal resources of Peshkopia Area have been estimated to be similar to those of Tirana- Elbasani area.

Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs.

5. DIRECTIONS FOR THE DIRECT USE OF GEOTHERMAL ENERGY OF LOW ENTHALPY IN ALBANIA

The geothermal situation of low enthalpy in Albania offers three possibilities for the direct use of geothermal waters energy. Geothermal energy utilization must be realized by an integrated scheme of geothermal energy, heat pumps and solar energy, and the cascading use of this energy (Frasheri A. 2001, Frasheri A. et al. 2003, 2004).

Firstly, the Ground Heat can be use for space heating and cooling by the Borehole Heat Exchanger-Geothermal Heat Pumps modern systems.

Secondly, thermal sources of low enthalpy and of maximal temperature are up to 65.5°C.

Thermal waters of springs and wells may be used in several ways:

1. Modern SPA clinics for treatment of different diseases and hotels, with thermal pools, for the development of eco-tourism. Such centers may attract a lot of clients not only from Albania, because of the curative properties of waters and springs are situated near the seaside, the Gjinari mountains or Ohrid Lake pearl.

The oldest and most important thermal springs are at the Elbasani Llixha SPA, located in Central Albania. By national road communication, the Llixha area is connected with Elbasani. These thermal springs from about 2000 years ago are known, near the old road “Via Egnatia" that has passed from Durresi-Ohrid- to Constantinople. All seven groups of the springs in Llixha Elbasani and Kozani-8 well, near of Saint Vladimir Monastery at Elbasani, have the possibilities for modern complex utilization. Ishmi 1/b geothermal well is located in beautiful the Tirana field, near the Mother Theresa- Tirana Airport, close to the Adriatic coastline and the Kruja - Skenderbeg Mountain.

Peshkopia SPA was constructed by modern concepts as balneological geothermal center. There are thermal pools, for medical treatment and recreation. Construction of the Peshkopia SPA must be en good example for new SPA construction in Albania.

2. The hot water can be used also for heating of hotels, SPA and tourist centers, as well as for the preparation of sanitary hot water used there. Near these medical and tourist centers it is possible to build greenhouses for flowers and vegetables, and aquaculture installations.

3. From thermal mineral waters it is possible to extract very useful chemical microelements as iodine, bromine, chlorine etc. and other natural salts, so necessary for preparation of pomades for the treatment of many skin diseases as well as for beauty treatments. From these waters it is possible to extract sulphidric and carbonic gas.

Thirdly, the use of deep doublet abandoned oil and gas wells and single wells for geothermal energy, in the form of a “Vertical Earth Heat Probe”. The geothermal gradient of the Albanian Sedimentary Basin has average values of about 18.7 mK·m-1. At 2 000 m depth the temperature reaches a value of about 48°C. In these single abandoned wells a closed circuit water system can be installed. Greenhouses can be built near these wells.

Consequently, the sources of low enthalpy geothermal energy in Albania, which are at the same time the sources of multi-element mineral waters, represent the basis for a successful use of modern technologies for a complex and cascading utilization of this environmentally friendly renewable energy, thus achieving economic effectiveness. Such developments are useful for the creation of new working places and improvements to the standard of living for local communities near thermal sources.

6. CONCLUSIONS

Albania has geothermal energy resources, which can be directly used as alternative, environmental friendly energy.

2. Resources of the geothermal energy in Albania are;

Natural springs and deep wells with thermal water, of a temperature up to 65.5°C.

Heat of subsurface ground, with an average temperature of 16.4oC and depth Earth Heat Flow.

3. Construction of a space-heating system, based on direct use of ground heat, by using the shallow borehole heat exchanger (BHE)-Heat Pumps systems, are actually the most important usage of geothermal energy.

7. ACKNOWLEDGMENTS

The authors express their thanks to their colleagues of the Geothermal Team at the Faculty of Geology and Mining of the Polytechnic University of Tirana and the Geophysical Institute at Academy of Sciences of the Czech Republic in Prague, for their scientific collaboration and help in our studies of geothermal energy.

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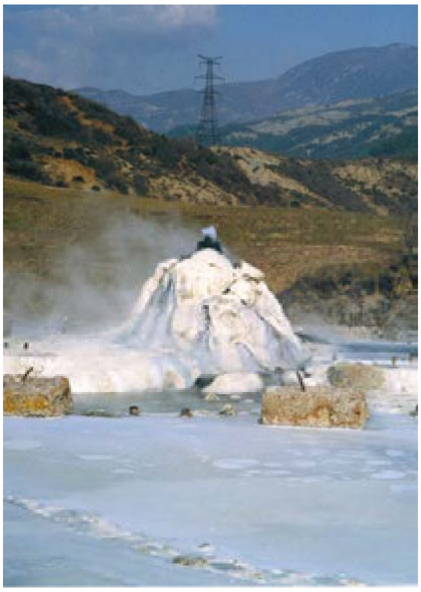


Photo 1. Langarica-Permeti thermal water springs

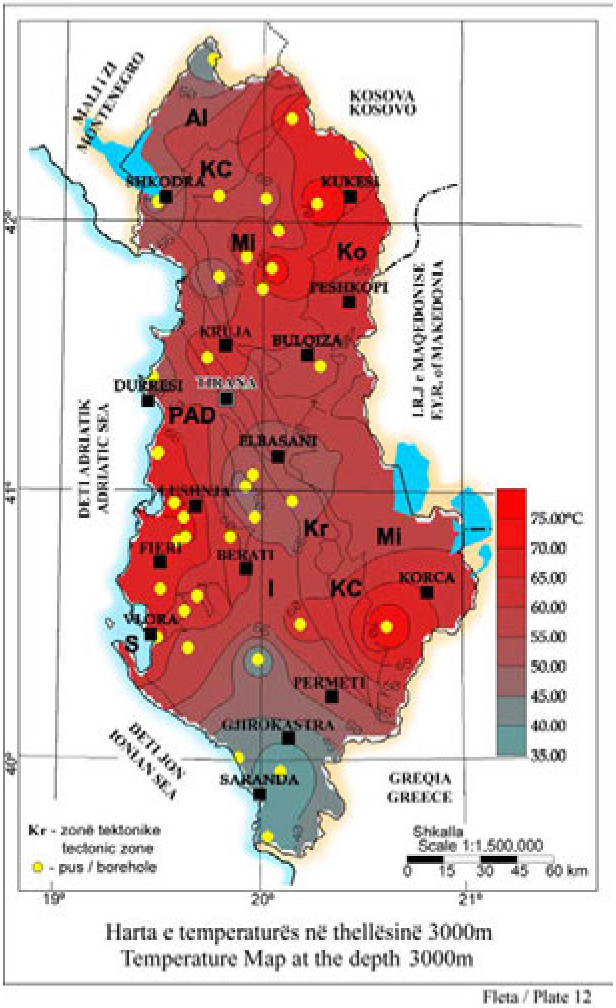
Photo 2. Geothermak deep well Kozani – 8

Table 1: Thermal Water Springs In Albania

N° of Springs	Location	Temperature in °C	Salt in mg/l	Artesian Spring yield in l.s-1
1	Llixha Elbasan	60	0.3	0
2	Peshkopi	5-43	9	10
3	Krane-Sarande	34		<10
4	Langarica-Permet	6-31		>10
5	Shupal-Tirana	29.5		10
6	Sarandoporo-Leskovik	26.7		>10
7	Tervoll-Gramsh	24		>10
8	Mamurras-Tirane	21	26	>10
9	Steam Postenani springs			

Table 2: The Oil And Gas Wells That Have Self-Discharge Of The Thermal Water,

N°	Well Name	Temperature in °C	Salt in $mg.l^{-1}$	Self-discharge in $l.sec^{-1}$
1	Kozani	65.5	4.6	10.4
2	Ishmi	64	19.3	4.4
3	Galigati	45-50	5.7	0.9
4	Bubullima	48-50	35	
5	Ardenica	38		15-18
6	Ardenica	32		
7	Semani	35		5
8	Verbasi	29.3		1-3



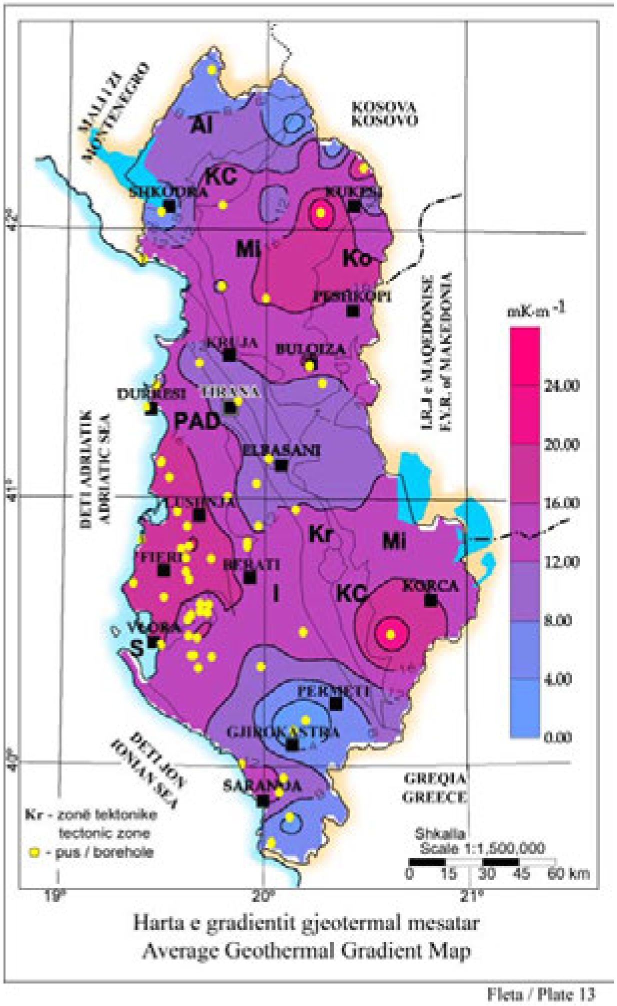
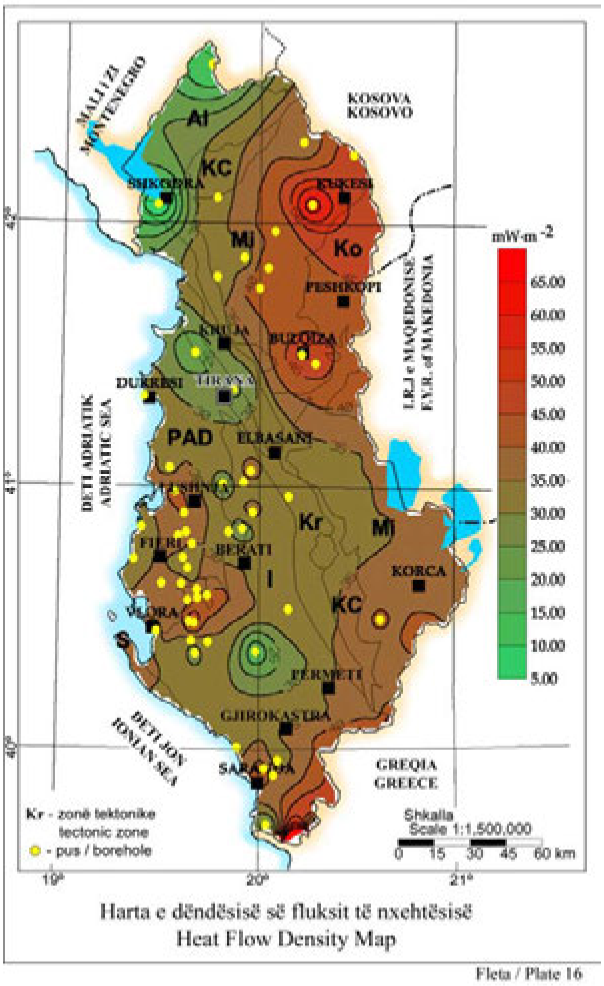


Figure 1 **Figure 2**



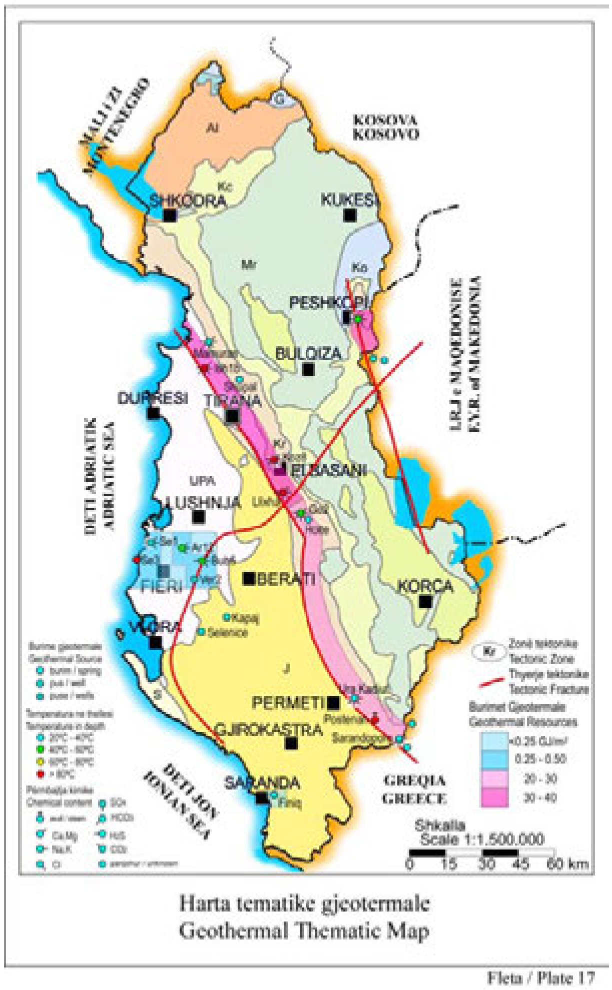


Figure 3 **Figure 4**

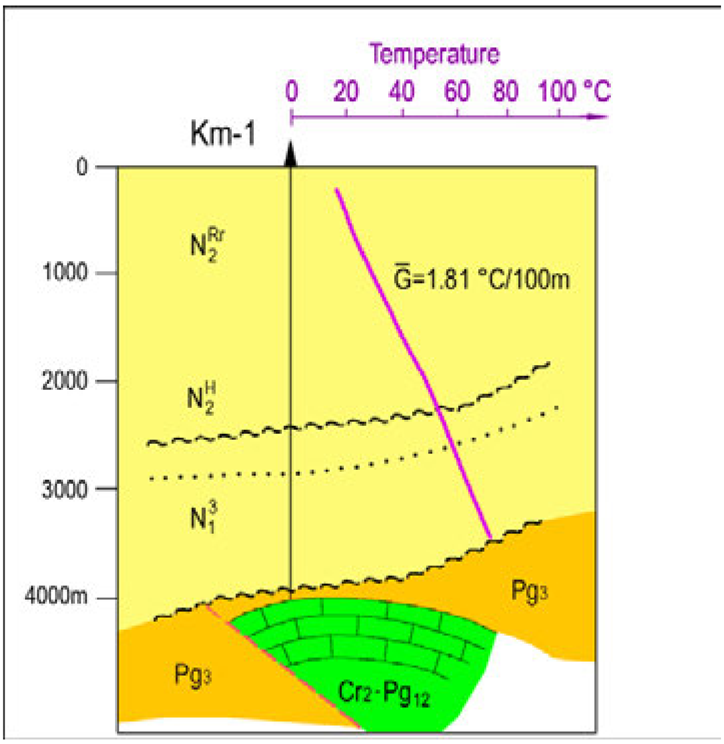


Figure 5

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY (Installed capacity

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr
In operation in December 2004			224	81	1446	4876					1670	4957
Under construction in December 2004												
Funds committed, but not yet under construction in December 2004											220	390
Total projected use by 2010			839	3781	1646	6870					2475	10651

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2004 (other than heat pumps)

[1)] I = Industrial process heat
H = Individual space heating (other than heat pumps)
C = Air conditioning (cooling)
D = District heating (other than heat pumps)
A = Agricultural drying (grain, fruit, vegetables)
B = Bathing and swimming (including balneology)
F = Fish farming
G = Greenhouse and soil heating
K = Animal farming
O = Other (please specify by footnote)
S = Snow melting

[2)] Enthalpy information is given only if there is steam or two-phase flow

[3)] Capacity (MWt) = Max. flow rate (kg/s)[inlet temp. (°C) - outlet temp. (°C)] x 0.004184 (MW=106 W)
or = Max. flow rate (kg/s)[inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

[4)] Energy use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.1319 (TJ=1012 J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.03154

[5)] Capacity factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171
Note: the capacity factor must be less than or equal to 1.00 and is usually less, since projects do not operate at 100% of capacity all year.

Note: please report all numbers to three significant figures.

Locality	Type[1)]	Maximum Utilization					Capacity[3)]	Annual Utilization		
		Flow Rate	Temperature (°C)		Enthalpy[2)] (kJ/kg)			Ave. Flow	Energy[4)]	Capacity
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5)]
Llixha Elbasan	B	15	60	18			2.64	9	3.56	0.042
Peshkopi	B	16	43	18			1.49	6	2.4	0.051
Hydrat	B	18	55	18			2.78	3	1.19	0.013
Ishmi	B	3.5	64	18			0.61	2.5	0.99	0.019
Kozani	B	10.3	65.5	18			2.05	1	0.39	0.006
TOTAL		62.8					9.57	21.5	8.53	0.131

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2004

[1] Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (^oC) - outlet temp. (^oC)] x 0.004184
or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001
[2] Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (^oC) - outlet temp. (^oC)] x 0.1319 (TJ = 1012 J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg) x 0.03154
[3] Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171 (MW = 106 W)
Note: the capacity factor must be less than or equal to 1.00 and is usually less,
since projects do not operate at 100% capacity all year

Note: please report all numbers to three significant figures.

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3]
Individual Space Heating[4]	---	---	---
District Heating [4]	---	---	---
Air Conditioning (Cooling)	---	---	---
Greenhouse Heating	---	---	---
Fish Farming	---	---	---
Animal Farming	---	---	---
Agricultural Drying[5]	---	---	---
Industrial Process Heat[6]	---	---	---
Snow Melting	---	---	---
Bathing and Swimming[7]	9.57	8.53	0.131
Other Uses (specify)	---	---	---
Subtotal			
Geothermal Heat Pumps	---	---	---
TOTAL	9.57	8.53	0.131

[4] Other than heat pumps
[5] Includes drying or dehydration of grains, fruits and vegetables
[6] Excludes agricultural drying and dehydration
[7] Includes balneology

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2000 TO DECEMBER 31, 2004 (excluding heat pump wells)

[1)] Include thermal gradient wells, but not ones less than 100 m deep

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)	
		Electric Power	Direct Use	Combined	Other (specify)		
Exploration[1)]	(all)						
Production	>150° C						
	150-100° C						
	<100° C		2			3.5	
Injection	(all)						
Total			2			3.5	

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES
(Restricted to personnel with University degrees)

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Programs
(6) Private Industry

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2000			2			95
2001			2			110
2002			2			110
2003		5	13			115
2004		5	9			135
Total		10	28			566

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2004) US$

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1990-1994	0.009		1.525		0.164	1.37
1995-1999	0.046		1.722		0.755	1.013
2000-2004	0.06		2.071		1.151	0.98

Geophysical features of the Alpine Mediterranean Folded Belt, in the Albanides framework

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Summary

Distribution of gravity, magentic and geothermal fields, and their anomalous features in Albanides onshore and in the Albanian Adriatic Shelf in this paper are presented. There are presented also a hydrographical-geothermal phenomenon in the Albanian Adriatic Sea area, which are correlated with Albanides geological setting.

Key words: Geothermal, Gravity, Heat Flow, Interpretation, Magnetics.

Introduction

The Albanides represent the assemblage of the geological structures in the territory of Albania, and together with the Dinarides at the North and the Hellenides at the South, have formed the southern branch of the Mediterranean Alpine Belt.

Integrated onshore and offshore regional geophysical studies have been performed for the exploration of the Albanides. Seismological studies, gravity and magnetic surveys, reflection seismic lines, geothermal studies, radiometric investigations, vertical electrical soundings and integrated well loggings represent the applied complex of the geophysical investigation. The structural analysis of the Albanides according to the integrated geophysical investigations, in the framework of the integrated interpretation with geological studies results is presented. Integrated oceanographic, hydrographic and hydrological observations and study have been carried out in the Adriatic and Ionian seas, and littoral areas.

Methods

Regional Gravity and Magnetic Mapping of Albanian onshore territory have been performed at the scale 1:200.000. For the western oil and gas bearing regions of Albania have the gravity map of Bouguer Anomaly at scale 1.100.000.

The studies on the geothermal field and evaluation of the geothermal energy in Albania, in the framework of the preparation of “Atlas of Geothermal Resources in Albania”, were performed on the basis of temperature logs in the 84 deep oil and gas wells and in 59 shallow boreholes. The temperature was measured with either resistance or thermistor thermometers. The thermal inertia of these thermometers is 5-6 seconds and 3.5 seconds, respectively. Laboratory of Department of Geothermics of the Geophysical Institute, Czech Academy of Sciences, Prague the thermal conductivity of the rocks was determined. The heat-flow density was calculated. Heat-flow density calculations were made for homogenous lithology part of geological sections, according to several models. The temperature maps at 100, 500, 1000, 2000, 3000 meters depths, average geothermal gradient map, heat flow density map and geothermal zones map, by the processed data were compiled. The maps of the Albanian territory have been linked with Greek and Adriatic space ones. Estimation of the geothermal resources of the thermal zones has been performed, based on a volumetric heat content of the model assuming exploitation of geothermal energy by a doublet or a singled wells system.

Oceanographic, hydrographical and hydrological studies are based on multi annual observations in the hydrometric station network since 1958 and on two Albanian oceanographic expeditions “Saranda-1963” and “Patos-1964” in the Southern Adriatic and Northern Ionian. The objects of these studies were: water levels, temperatures and chemical content, formation and circulation of the water mass, wave and wind regimes of the Adriatic and Ionian coastline, water potential and run-off discharge regime of the Albanian Mountainous River System into the Adriatic Sea, suspended material discharge; alluvial granulometric composition, water chemical composition etc.

Analysis and discussions

Seismological studies, regional gravity and magnetic survey data reflect the Earth Crust configuration [Bushati S. 1988, 1997, Frashëri A. et al. 1996, 2004]. Geophysical data reveal that the Earth crust becomes thicker from the central regions of the Adriatic towards Albanides inland. The sedimentary crust has about 10 km thickness in Adriatic seashore and reaches up to 15 km in northwestern regions of Albania. Rocks, with a seismic wave velocity of 5.9- 6.2-km/sec, present the lower part of the sedimentary crust. These rocks have a very consolidated structure. In the Albanides are fixed four of third order trends of the Bouguer anomalies: two maximums two minimums (Fig. 1). The main gravity maximum is extended on the northeastern part of the Albania. The second maximum, which is located in the southwestern part of Albania, has a sub-transversal strike with geological structures of the Ionian tectonic zone. These regional gravity maximums are

attributed to a crust thinning. The second minimum is located in the Alps tectonic zone, by a strike in the SE-NW direction. Generally, the Bouguer anomaly increases from the Adriatic Sea Shelf to the Eastern part of the Albanides. The geological-geophysical profile Albanid 1 presents the decreasing of the depth of roof of the Moho discontinuity in Adriatic Sea region. The Moho discontinuity plunges from 25 km in the central part of the Adriatic Sea to 43- 52 km at eastern part of Albanides. Regional gravity anomalies are caused by a block construction of the crust, which comes out from the results of seismological studies. This tectonic setting of the deep levels of the earth crust in the Albanides finds its reflection even in the distribution of the magnetic fields (Fig. 2). The interpretation of the regional magnetic anomalies shows that the top of the crystal basement plunges toward the littoral of the Albanides up to their central areas.

The tectonic setting of the deep levels of the Albanides Earth Crust and their dynamics has conditioned the geology and tectonic style of Albanides.

Geological and geophysical regional studies, have distinguished the following tectonic zones:

1. Internal Albanides: Korabi, Mirdita, Gashi tectonic zones,
2. External Albanides Albanian Alps, Krasta-Cukali, Kruja, Ionian, Sazani tectonic zones, and Peri Adriatic Depression.

Intensive Bouguer anomalies and very turbulent magnetic field, with weak anomalies (Fig. 1), characterize the ophiolitic belt of the Mirdita tectonic zone in the Internal Albanides. The ophiolitic belt has its biggest thickness about 14 km at its northeastern extreme, in the ultrabasic massif of Kukes. This thickness is reduced up to 2 km towards the west and the southeast. This interpretation is demonstrated a allochton character of ophiolite belt and the covering character of the western contact of ophiolites with the formation of External Albanides. The relations between the Internal and the External Albanides have a nappe character. The separation of the gravity and the magnetic anomalous belts in the central region of the Internal Albanides, at Shengjergji flysch corridor, arguments the presence of Diber-Elbasan-Vlora transversal fault.

A joint characteristic of structural belt in the External Albanides is their westward thrusting, too. Açording to the integrated geological-geophysical studies and deep well data results that two tectonic styles are observed in the Ionian tectonic zone: duplex and imbricate tectonic. Traversal faults have separated the Ionian basin in several blocks. Following limestone top of the south Adriatic basin and Sazani, Ionian and Kruja zones are observed that the limestones of the southern Adriatic basin are extended under the last units. Peri-Adriatic Miocene and Pliocene molasses deposits cover partly the Sazani, Ionian and the Kruja tectonic zones. They are placed trangressively over the older section down to the limestone of the Eocene, creating a two-stage tectonic stage. The molasses post-orogenic deposits have covered transgressively Mirdita and partially Krasta–Cukali tectonic zones in Korça and Burreli basins.

The interpretations of the geological geophysical data lead to a new structural model and tectonic style of the External Albanides. Tectonic zones of the External Albanides have been in compression tectonic regime since upper Jurassic-Cretaceous. Whereas, western part, of Apulian zone and South Adriatic basin, it happens in continuous extension tectonic regime [Meço S. and Alias Sh. 2000]. Overthrusting style of the southeastern part of the External Albanides, with a great southwestward overthrust of the anticline chains, and the presence of the old transversal faults already are well known. Evaporite deposits have been the lubrication substratum during the over thrusting movement. A regional neotectonic phenomenon is also the back thrusting tectonics in the Ionian and Sazani zones. The Albanian sedimentary basin continues even in Adriatic shelf with carbonate and terrigene formations. In the different profiles it is noticed that there exist some local Bouguer and magnetic anomalies in Adriatic shelf [Richeti G. 1980].

Geothermal Regime

The Geothermal Regime of the Albanides is conditioned by tectonics of the region, lithology of geological section, local thermal properties of the rocks and geological setting. The geothermal field is characterized by a relatively low value of temperature. The temperature is 105.8°C at 6000 meters depth, in the central part of the Peri-Adriatic Depression. The isotherm runs parallel the Albanides strike. The described geothermal field, with relatively low values of temperature, is a characteristic of the sedimentary basins with a great thickness of sediments. The temperatures in the ophiolitic belt are higher than in sedimentary basin, at the same depth. In the External Albanides the geothermal gradient is relatively higher. The geothermal gradient displays the highest value of about 21.3 $mK.m^{-1}$ in the Pliocene clay section in the center of Peri-Adriatic Depression. Elsewhere in Ionian zone, the gradient is mostly 15 $mK.m^{-1}$. The modeling results show that deeper than 20 km is observed decreasing of the gradient (Fig. 3). This change of the gradient is coincided with the top of the crystal basement. In the ophiolitic belt of the Mirdita tectonic zone, the geothermal gradient values increase up to 36 $mK.m^{-1}$ at northeastern and southeastern part of the Albania. After the geothermal modeling, decreasing of the gradient is observed also deeper than 12 000 meters, at the top of the Triassic salt deposits.

The regional pattern of heat flow density in Albanian territory is presented in the Heat Flow Map (Fig. 4). There

are observed two particularities of the scattering of the thermal field in Albanides:

Firstly, the maximal value of the heat flow is equal to 42 mW/m^2 in the center of Peri-Adriatic Depression of External Albanides. The 30 mW/m^2 value isotherm is open towards the Adriatic Sea Shelf. Heat flow density values are lower than 25-30 mWm^{-2} in Albanian Alps area.

Secondly, in the ophiolitic belt at eastern part of Albania, the heat flow density values are up to 60 mW/m^2. The contours of Heat Flow Density give a clear configuration of ophiolitic belt. Radiogene heat generation of the ophiolites is very low. In these conditions, increasing of the heat flow in the ophiolitic belt is linked with heat flow transmitting from the depth. Ophiolitic belt Heat Flow Density highest value can be explained by the small thickness of the geological section down to the top of crystalline basement, and MOHO discontinuity. The granites of the crystalline basement, with the radiogenic heat generation, represent the heat source. In the ophiolitic belt there are some hearths observed of higher heat flow density. Heat flow anomalies are conditioned by intensive heat transmitting through deep and transversal fractures.

Large numbers of geothermal energy of low enthalpy resources are located in Albania. Thermal waters with a temperature that reach values of up to 65.5°C are sulphate, sulphide, methane, and iodinate-bromide types. The Earth crust in the Albanides is interrupted by a system of longitudinal fractures in NW-SE direction and transversal fractures that touch the mantel. The geothermal energy of the Albanides is linked with these deep fractures.

Adriatic Sea Hydrographic-Geothermal Phenomenon

Based on two Albanian Oceanographic Expeditions data have been argumented that the total discharges of the Albanian rivers system in the Adriatic and Ionian Seas have a minimal discharge is 700-800 m^3/s for the hydrological dry years of low precipitation and maximal values 1900-2200 m^3/s for the hydrological wet years of high precipitation (Pano N. 1994). The oceanographically situation of the wet years has been characterized by formation of "The Bridge" of continental water with low salt content and density of the seawaters in the Adriatic Sea. Under “The Bridge” is located also a heat flow density anomaly at the sea bottom (Fig. 4). The “Bridge” direction is corresponds also with the prolongation of well-known Scutary-Pec regional tectonic transversal over the Albanides onshore. This “Bridge” has impact also on the seawater temperature distribution in this area. “The Bridge” includes the surface layer and Levant Intermediate Water (LIW) up to 600 m. depth. This phenomenon has an important influence on dynamics and formation Adriatic Deep Water (ADW).

Conclusions

1. Integrated Geophysical Syrveys have studied Albanides Earth Crust and have distinguished two palaeogeographical units and tectinic zones.
2. The Earth crust in the Albanides is interrupted by a system of longitudinal fractures in NW-SE direction and transversal fractures that touch the mantel.

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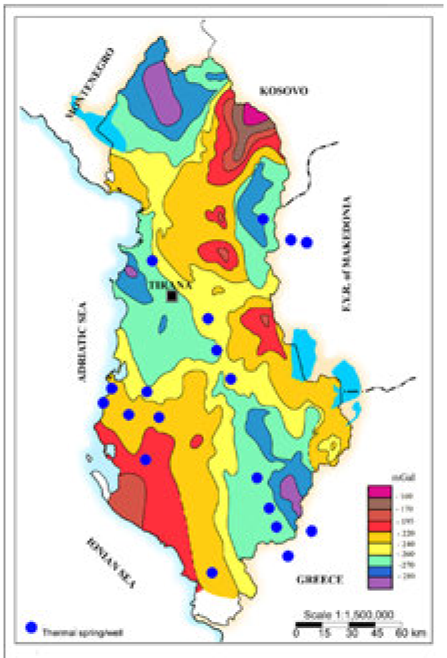
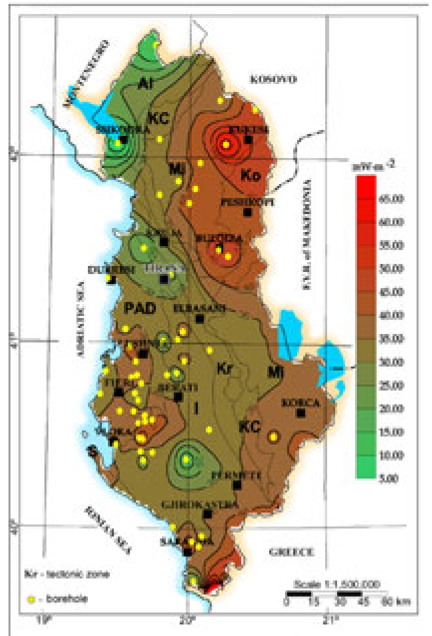
Fig. 3



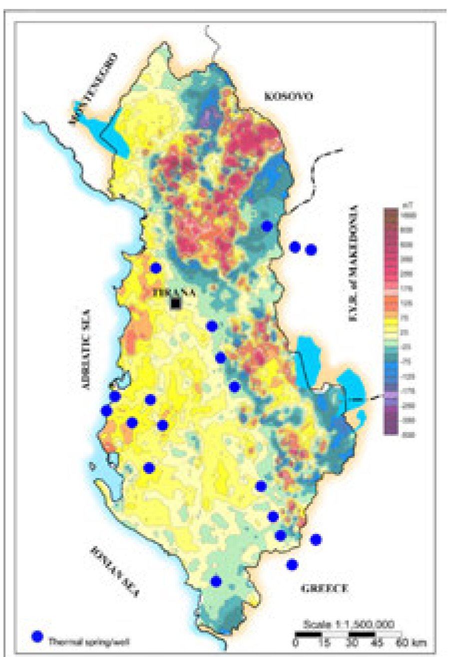
Bouguer Gravity Anomalies Map

Fig.1



Heat Flow Density Map

Fig. 2



Total Magnetic Field Map

Fig. 3

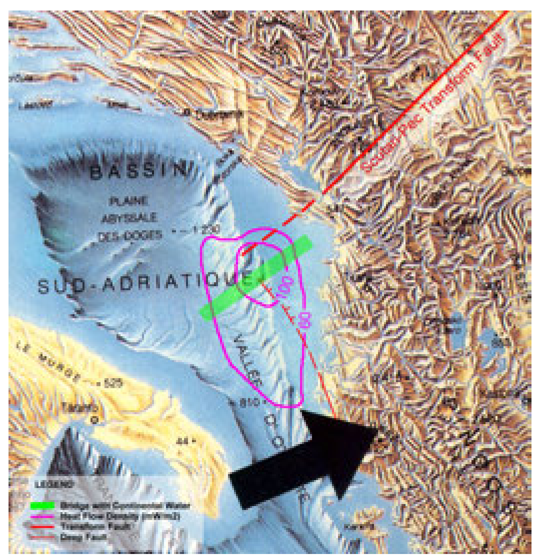


Fig. 4. Correlation of “The Bridge” of continental water Adriatic, Heat Flow Density anomaly and. Scutary-Pec regional tectonic tranvesal fault.

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SGP-TR-179

DIRECT USE OF GROUND HEAT FOR SPACE HEATING AND COOLING, IN THE LOW ENTHALPY GEOTHERMAL ENERGY AREAS PRESENT A CONTRIBUTION IN COUNTRY ENERGY SYSTEM

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ABSTRACT

In the paper a detailed analyse of the shallow ground heat resources in Albania, in particularly in Tirana city, and ways for direct use of this energy concretely for heating in Tirana is presented. Direct use of the ground heat by Borehole heat Exchanger-Geothermal Heat Pump for space heating and cooling, was programmed to develop in Albania.

1. Introduction

Large numbers of geothermal energy of high and low enthalpy resources, a lot of mineral water sources represent the base for successfully application of modern technologies in Albania, to achieve economic effectiveness. There are many thermal springs and wells. Their water has temperatures that reach values of up to 65.5°C.

The geothermal situation of low enthalpy in Albania offers following directions for the exploitation of geothermal energy (Frashëri et al. 2003):

Firstly, space heating and cooling

Secondly, integrated and cascade use of geothermal waters energy

The most important direction is space heating and cooling. The Earth Heat can be use for space heating and cooling by modern systems Borehole Heat Exchanger-Geothermal Heat Pumps.

In the paper is presented a detailed analyse of the shallow ground heat resources in Albania, in particularly in Tirana city, and ways for direct use of this energy concretely for heating in Tirana.

2. Presentation of the problem

The energy crisis prevailing in the Albania, the increased demand in premises, the gradual implementation of European standards of premises' heating, are all decisive factors raising the awareness in order to contribute in finding optimal solutions to this critical situation. Actually, the electric energy consummation for heating is 1 375 GWh/year, or 23.8 % of the total electric energy

production in Albania (Fig. 1) (National Agency of Energy, Tirana, 2003). The situation becomes more problematic because the use of natural gas for heating emits large quantities of CO_2 in the atmosphere.

The Earth's heat is a great source of energy, renewable and friendly to the environment. Direct use of the ground heat by Borehole heat Exchanger-Geothermal Heat Pump represents a modern system for space heating and cooling. Two shallow geothermal sources exist: Ground heat

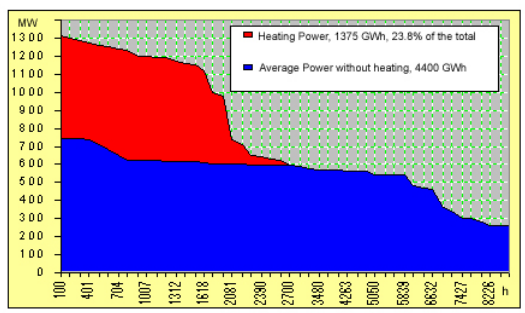

Fig. 1. Electrical power for heating and average power without heating in Albania. (National Agency of Energy)

through use of the ground-couplet (closed loop), and underground water system (open loop).

Alike elsewhere in the world, in Albania the subsurface ground layers contain heat. This energy can be successfully exploited in heating the public premises (offices, hospitals, libraries, theatres, airports etc.) as well as private premises (houses and apartment buildings), using the modern systems of Borehole-Heat Exchanger-Geothermal Heat Pumps.

Two kind of technology is possible to applied (Lund J. W. 1996, Rybach L. et al. 2000):

Firstly, ground-source and Borehole heat Exchanger-Geothermal Heat Pump or ground-couplet (closed loop) (Fig. 2),
Secondly: underground water system – Geothermal Heat Pump (open loop).

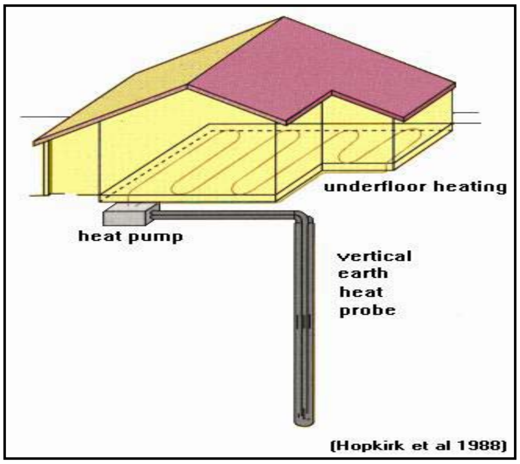

Fig. 2. Borehole- Vertical Heat Exchanger-Geothermal Heat Pump System for space heating and cooling scheme.

Actually, these modern systems in use, highly effective and with low consume of electric energy, technologically advanced and environmental friendly, are gaining huge popularity (Curtis, et al. 2005, Lund, 1996, Rybach, et al. 2000, Rybach, 2005, Sanner, 2004).

In order to make use of this renewable geothermal energy and environmental friendly ground heat for space heating and cooling in Albania, we have introduced the idea of building a demonstrative installation for heating and cooling purposes in Tirana (Frashëri et al. 2003). The implementation of this project contributes in raising the awareness of the public administration, of the business and scientific communities, to make use of this economically optimal solution for heating and cooling of premises. The public administration should introduce the necessary tools and incentives for enabling the entering into the market of such modern and environmentally friendly systems. The business community should have in consideration and invest in installation of these Borehole-Heat Exchanger-Geothermal Heat Pumps, making way for new businesses. The universities should teach about these modern systems and insists on their applicability.

3. Ground Geothermal Energy Resources in Tirana City Heat quantity, temperature at Earth surface, and geothermal gradient in shallow geological section, are conditioned by geographical location, geomorphological conditions (Earth surface dip and position in relation by Sun), ground and bedrocks lithology, specific heat and humidity, season and weather. According to the multi annual meteorological surveys result that in average is 140,000 calory.cm^{-2} heat from solar radiation of the ground during the summer at the plane areas of the Albania. Heat quantity reaches 120,000 calory.cm^{-2} at northeaster mountains regions [Gjoka L., 1990].

Thermal field distribution and geothermal gradient values in the ground at shallow geological section are conditioned that at the depth 100m the temperatures reaches from 16oC up to 18.8o at plane areas in the Ionian tectonic zone and in Peri Adriatic Depression (Fig. 3). The areas with a temperature between 18 °C and 19 °C are located at Kolonjë-Divjakë-Kryevidh, Vlorë and Sarandë-Delvinë zones. There are some particularities in the distribution of the temperature at the depth 100m:

Temperature in subsurface ground at littoral area:
Minimal temperature is 16.60 ^{o}C
Maximal temperature is 18.80 ^{o}C
Average temperature is 17.80 ^{o}C

Temperature in subsurface ground at western plane-hilly area:
Minimal temperature is 17.15 ^{o}C
Maximal Temperature is 18.41 ^{o}C
Average Temperature is 18.0 ^{o}C

Temperature in subsurface ground at hilly-mountains regions:
Minimal temperature is 6.70 ^{o}C
Maximal temperature is 18.60 ^{o}C
Average temperature is 14.75 ^{o}C

In plane area of Albania, example in the Tirana field (Rinasi), the temperature is 15.5 ^{o}C, up to logging depth 31 m, in the Quaternary deposits (Fig. 4) (Frashëri et al. 2003). According to the well-known data, the layers at the depth from 0-8-10 m have a temperature, which is conditioned by solar radiation energy. During the winter, the temperature is lower than during the summer. Below, the ground temperature is constant during the year, because don't have the influence from solar radiation. Depth limit of the solar radiation influence zone is not unique. Lateral changes up to 0.5 ^{o}C are observed in the 500m distances, for the same time. These lateral changes are conditioned by lithology of the Quaternary loose deposits. The belt of the constant temperature continues up to the depth 50 m in the mountain regions of the Albania.

Water temperature of the Quaternary sandstone layers is 15-16^{o}C

According to the analyze of the geothermal regime of the shallow geological section is concluded that is possible to use the ground heat for the space heating and cooling, applied modern Borehole Heat Exchanger – Geothermal Heat Pump.

Ground geothermal energy has heated the underground water reservoir. In Tirana underground water basin are following temperatures: Water temperature of the Quaternary gravel layer is 14-15 ^{o}C,

Consequently, concluded that water of the Tirana underground basin can be a heat source for the geothermal pumps (Fig. 5).

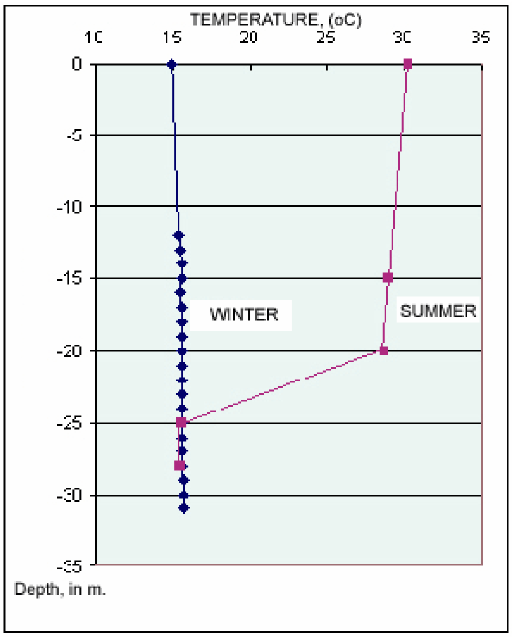

Fig. 4. Thermolog of the Rinasi borehole

4. Economic evaluation of the proposed scheme
Heating of the Hotel in Tirana:
Total heated surface, for three-floors: 610 m^2
Heating system: Borehole-Heat Pump-Radiators
Heating capacity 68.5 KW
Heating period 1836 hours

***Heating system*, there are analyzed three variants:**
a) Borehole-Geothermal Heat Pump
b) Oil Fired Boiler
c) Air-Air Conditioners

Installed cost for Borehole-Geothermal Heat Pump System:
Geothermal Heat Pump, with a heating capacity 68.5 kW, 19.840 USD/unit
Installation of the Geothermal Heat Pump System 1.800 USD
Heating and cooling equipment (radiators, pipes etc) and its installation in the room 16.7 USD/m^3, for 1830 m^3 for all building 25.860 USD
Providing water to the geothermal heating pump and re-injection of water in the collector after the use (Shallow boreholes, circulating pump, pipeline), according to the price index in Tirana: 7.500 USD.
Total 55.000 USD
90,16 USD/m^2

Preliminary installed cost for three systems:
a) Borehole-Geothermal heat pump 55.000 USD
b) Borehole-Vert. Heat Exchanger-heat pump 87.630 USD
c) Oil Fired Boiler 26.880 USD
d) Air-air conditioners, type “General” 19.970 USD

Preliminary installed cost for square meters of heated surface:
a) Borehole-Geothermal Heat Pump 90,16 USD/m^2
b) Borehole-Vertical Heat Exchanger-Heat Pump 144,17 USD/m^2
c) Oil Fired Boiler 57,04 USD/m^2
d) Air-Air Conditioners, type “General” 33,28 USD/m^2

Preliminary electric energy or fuel yearly consumption (operating) cost:
a) Borehole-Geothermal Heat Pump 33.304 KW/y 4.332 USD/y
b) Oil Fired Boiler 12.282 Lit. oil/y 15.337 USD/y
c) Air-air conditioners 93.636 KW/y 12.179 USD/y

Preliminary total yearly heating energy cost (installed and operating cost):

- **USD/kW**	*First year*	*Second year*
a) Borehole-Geothermal Heat Pump	866,74	63,23
b) Borehole-Vert. Heat Excanger-Heat Pump	1.342.50	63,23
c) Oil Fired Boiler	728,42	177,80
d) Air-air conditioners	469,49	261,48

- **USD/m^2**		
a) Borehole-Geothermal Heat Pump	97,33	7,10
b) Borehole-Vert. Heat Exchanger-Heat Pump	150,76	7,10
c) Oil Fired Boiler	81,79	19,64
d) Air-Air Conditioners	52,72	15,60
e) Electrical Radiators	29,36	29,36

Electric energy or fuel yearly consumption (operating) cost total yearly heating energy cost (installed and operating cost) during 10 years of the different heating system using in the fig. 6 and 7 are presented.

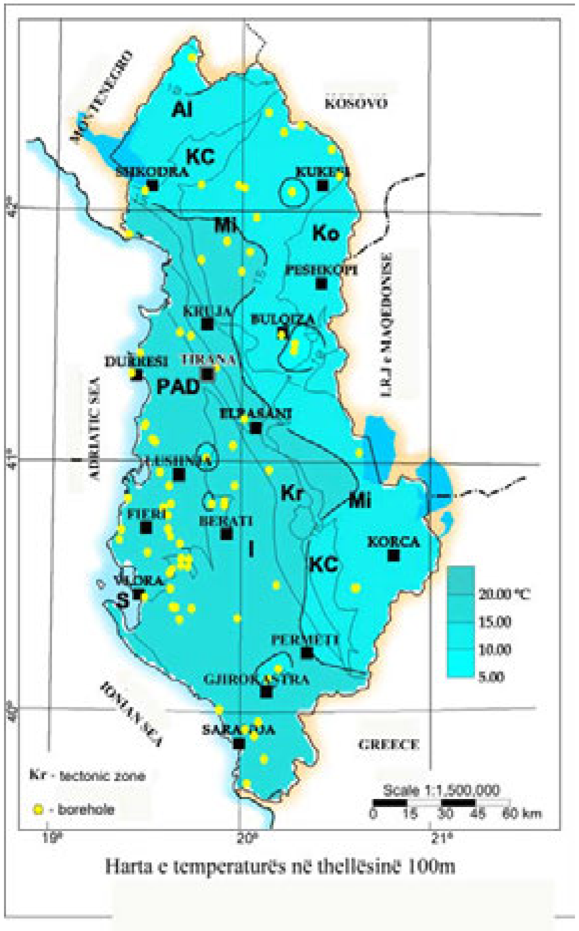
MONTENEGRO
KOSOVO
SHKODRA
KUKESI
PESHKOPI
KRUJA
BULQIZA
DURRESI
TIRANA
PAD
ELBASANI
LUSHNJA
FIERI
BERATI
KORCA
VLORA
PERMETI
GJIROKASTRA
SARANDA
GREECE
ADRIATIC SEA
IONIAN SEA
I.R.J e MAQEDONISE
20.00 °C
15.00
10.00
5.00
Kr - tectonic zone
- borehole
Scale 1:1,500,000
0 15 30 45 60 km
Harta e temperaturës në thellësinë 100m

Fig. 3

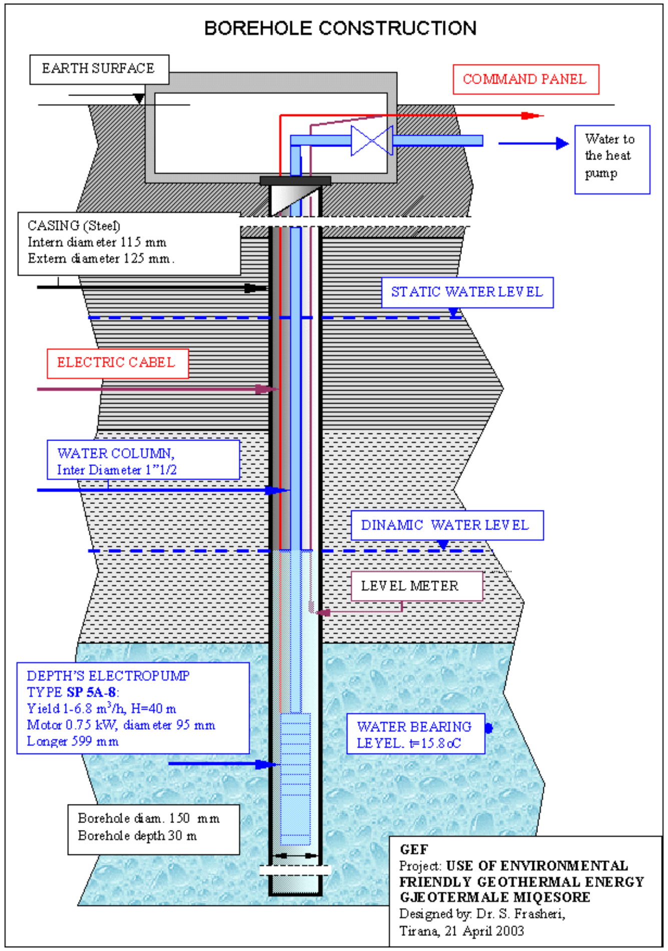
BOREHOLE CONSTRUCTION
EARTH SURFACE
COMMAND PANEL
Water to the heat pump
CASING (Steel)
Intern diameter 115 mm
Extern diameter 125 mm.
STATIC WATER LEVEL
ELECTRIC CABEL
WATER COLUMN,
Inter Diameter 1"1/2
DINAMIC WATER LEVEL
LEVEL METER
DEPTH'S ELECTROPUMP
TYPE SP 5A-8:
Yield 1-6.8 m³/h, H=40 m
Motor 0.75 kW, diameter 95 mm
Longer 599 mm
WATER BEARING LEVEL. t=15.8 oC
Borehole diam. 150 mm
Borehole depth 30 m
GEF
Project: USE OF ENVIRONMENTAL FRIENDLY GEOTHERMAL ENERGY GJEOTERMALE MIQESORE
Designed by: Dr. S. Frasheri,
Tirana, 21 April 2003

Fig. 5

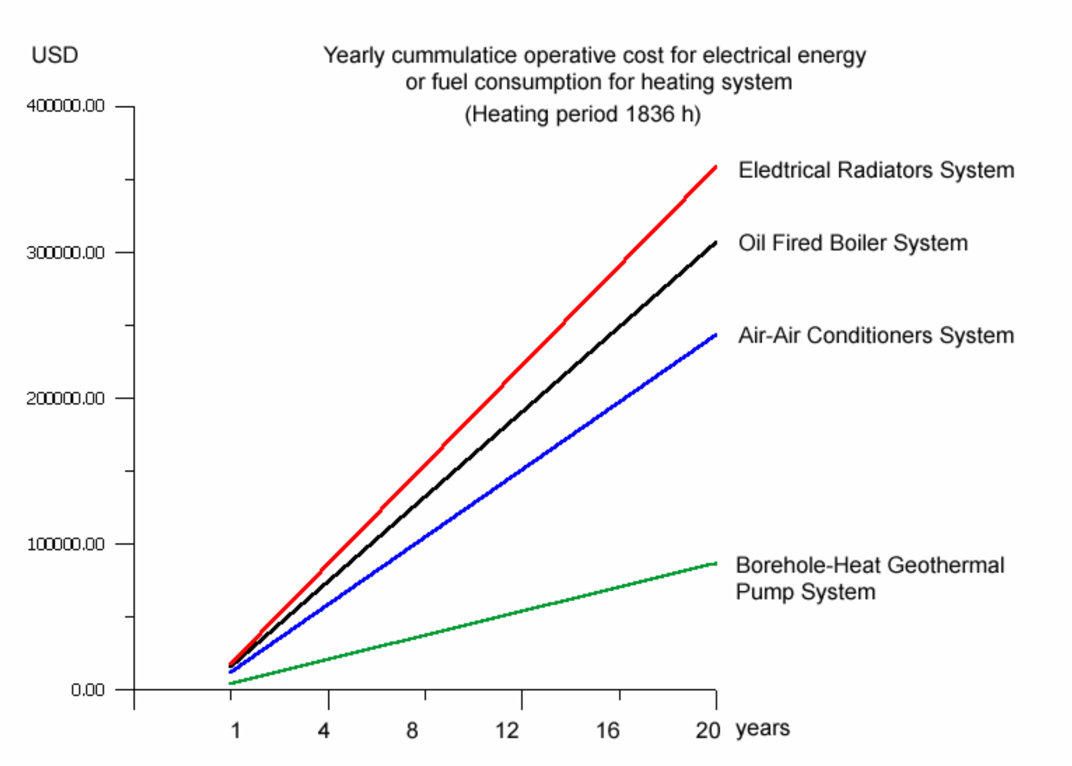
USD
Yearly cummulatice operative cost for electrical energy
or fuel consumption for heating system
(Heating period 1836 h)
400000.00
300000.00
200000.00
100000.00
0.00
Eledtrical Radiators System
Oil Fired Boiler System
Air-Air Conditioners System
Borehole-Heat Geothermal
Pump System
1
4
8
12
16
20
years

Fig. 6

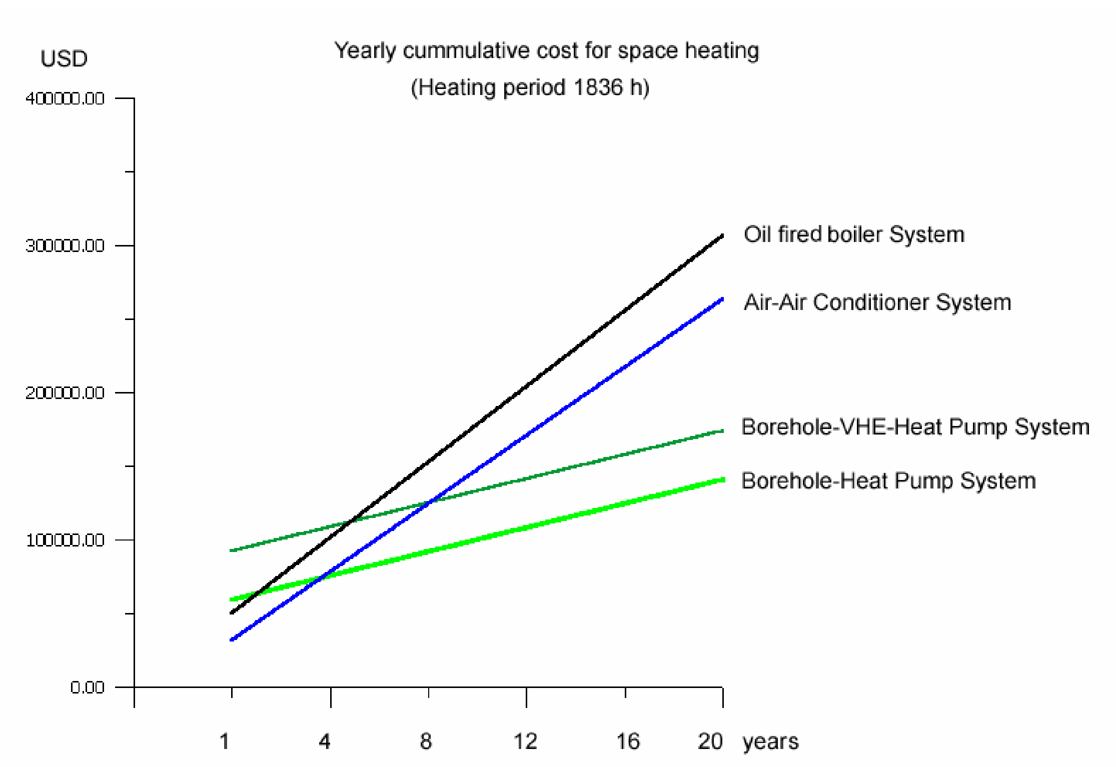
USD
Yearly cummulative cost for space heating
(Heating period 1836 h)
400000.00
300000.00
200000.00
100000.00
0.00
Oil fired boiler System
Air-Air Conditioner System
Borehole-VHE-Heat Pump System
Borehole-Heat Pump System
1
4
8
12
16
20
years

Fig. 7

Installed cost for geothermal system unit result 83-133 USD/m^2, and 744-1180 USD/kW, depended from the heat source. Borehole-Vertical Heat Exchanger-Geothermal Heat Pump System has the higher cost.

Lower costs have Borehole-Geothermal Heat Pumps systems, with shallow underground water heat source.

After the data presented in the fig. 5 and 6, results that installed cost for the geothermal systems is 2.0-2.8 much higher than for the boiler or air-air conditioner systems.

Payback period for the intalled cost for the "Borehole-Geothermal Heat Pump" System will be 2 years, covered only by expenses savings for boiler fuel, and 4 years, covered only by expenses savings for air-air conditioners.

Payback period for the intalled cost for the "Borehole-Vertical Heat Exchanger-Geothermal Heat Pump" System will be 4 years, covered only by expenses savings for boiler fuel, and 8 years, covered only by expenses savings for air-air conditioners.

In fig 8 is presented the graphic of the cost of space heating for different heating systems (in USD/kW). According to this graphic results that geothermal heating and cooling system is more economic system.

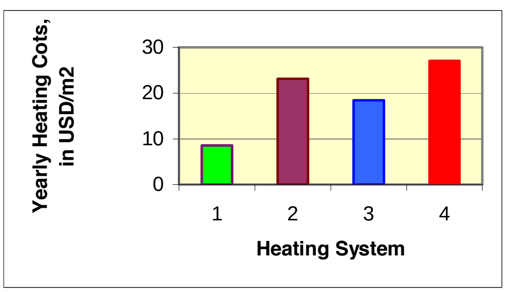

Fig. 8. Cost of space heating for different heating systems (in USD/m^2).
1- Geothermal System; 2- Oil Fired Boiler System; 3- Air-Air Conditioner System; 4- Electric Radiator System.

4. Call for investment

The heating problem and its economic solution is an important task, taking into consideration the current severe energetic crises. One of the ways out is the use of geothermal energy. In Albania there are many high-rise building, which are still projected to include oil or gas fired boiler systems, as well as with air conditioning units. Air conditioning units heat all public institutions. The hospitals, dorms, hotels are heated by oil and gas fired boilers. It is the ripe time to move out of such practices, which do not provide for long term sustainable solutions to the heating and cooling problems in Albania. It is the right time to introduce systems using renewable energy sources such as the geothermal energy.

In order to introduce the system of geothermal energy, a renewable and environmental friendly energy source, we propose to build a demonstrative installation, heating and cooling any given building in Tirana.

Implementing this project will provide for an optimal and economically efficient solution, which will be of benefit to the public administration, business community, as well as to the technical and scientific community. It will pave the way for a more economically efficient solution to heat and cool buildings. Optimally the government will promote and stimulate the introduction of such systems in Albania. In addition there are economic incentives for the business community to invest in this new venture, which we believe is the most sound solution for our country.

4.1. Project goal and objectives

4.1.1. Project goal:

a) Design and construction of the demonstrative space heating system, with underground waters or shallow ground heating sources.

b) Albanian investors and communities sensitizing for high economic effectiveness of integrated and cascade use of environmental friendly geothermal energy in Albania.

4.1.2. Objectives:

1. Design and construction of the demonstrative space heating system, in one of a new constructed or existing building, with oil fired boiler heating system..

2. Construction of the demonstrative space heating system.

3. Knowledge dissemination: Workshops, seminars, TV emissions, lectures in the Universities: "Space heating and cooling direct using of the environmental friendly geothermal energy, in the framework of the renewable energies use, to improve the country energy balance and an important profitable investment present"

4.1.3. Necessary Investment

It is necessary to match the installation of the demonstrative geothermal system to the size of the building. It is also necessary to have a building, which is heated by a boiler. Initially it would be

most suitable to build an installation, which will use underground water as the heat source. This will provide for a lower cost.

Based on feasibility study, the installed cost of geothermal heating system, with underground waters heat source will be 83-133 USD/m^2.

Direct use of the Geothermal Energy in Albania must start as soon as possible, first of all for the solving of the space heating and cooling. Will be high economic effectiveness investment:

Economical considerations (Curtis, et al. 2005, Lund, 1996, Rybach, et al. 2000, Rybach, 2005, Sanner, 2004). Actually, the cost of installing the Borehole-Heat Exchanger-Geothermal Heat Pump is higher than the conventional fuel installations. Nonetheless, the annual cost of "fuel" of the Borehole-Heat Exchanger-Geothermal Heat Pump (Electric energy for the heat pump and circulating pump) are considerably lower than the fuel of the conventional heating by gas. ***For the coefficient of performance 3, is saved up to 66% of the electrical energy.*** Consequently, the payback of the Borehole-Heat Exchanger-Geothermal Heat Pump system is shorter than the durability of using the other heating system.

Environmental considerations. Borehole-Heat Exchanger-Geothermal Heat Pump is an environmental system that does not emits CO2 ("greenhouse effect"), therefore the proprietor avoid paying the tax on emittance of CO_2 gas, which is under discussion in the countries of the European Community.

Governmental support. Japan using the geothermal energy of subsurface ground layers saves up to 40% of the total energy (Japan Times, Jan. 21, 2003). The expenses necessary to carry out this project will be paid within 10 years. Two thirds of the building costs, valued up to 10 million yen for the government and local authorities support each installation. The Japanese government has invested 200 USD for every kW of the Heat Geothermal Pump, with an upper limit of 5 200 USD.

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Platform for Projecting of Integrated and Cascade Use of Geothermal Energy of Low Enthalpy in Albania

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Abstract: *Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters are sulfate, sulfide, methane, and iodinate-bromide types. Thermal sources are located in three geothermal zones:*

- ***Kruja geothermal zone*** *represents a zone with bigness geothermal Identified resources in carbonate reservoirs,* $5.9x10^8$*-*$5.1x10^9$ *GJ,*
- ***Ardenica geothermal zone*** *is located in the coastal area of Albania, in sandstone reservoirs.*
- ***Peshkopia gjeotermal zone*** *at northeastern area of Albania. Several springs are located in disjunctive tectonics of the gypsum diapir.*

The geothermal situation in Albania offers three directions for the exploitation of geothermal energy:

- ***Use*** *of the heat flow of shallow geological section for heating and cooling of the buildings. Integrated exploitation of the geothermal energy must realize by integrated scheme of geothermal energy, heat pumps and solar energy to fulfill.*
- ***T****hermal sources of low enthalpy are natural sources or wells in territory of Albania. They represent the basis for a successful use of modern technologies for a* <u>*complex and cascade exploitation*</u> *of this energy, achieving an economical effectiveness:*

1. SPA clinics for treatment of different diseases and hotels for ecotourism.
2. The hot water for heating and sanitary waters of the SPA and hotels, greenhouses and aquaculture installations.
3. Extract of the chemical microelements from thermal waters.

- *Use of deep abandoned oil and gas wells as "Vertical Earth Heat Probe".*
  Actually in Albania the study of the possibilities of exploitation of the geothermal energy has begun.

Keywords: Geothermal Energy, Thermal Water, Geothermal Gradient, Heat Flow, Direct Use of Geothermal Energy

1. INTRODUCTION

In Albania, rich in geothermal resources of low enthalpy and mineral waters, new technologies of direct use of geothermal energy are still untouched. Actuality, there are many geothermal, hydrogeological, hydrochemical, biological and medical investigations and studies of thermal and mineral water resources carried out in Albania. The results of the geothermal studies carried out in Albania are presented in "Atlas of Geothermal Resources in Albania" [5]. The hydrogeology and geothermy of the natural springs with thermal waters and the geological structures with high water temperature have also been investigated. Generally, these investigations and studies are separated each from the other. Their information has been served for evaluations of the geothermal resources in Albania, in regional scale. According to results of these new studies, the evaluation for the perspective level of the best areas in country has been selected. After these evaluations is possible to start programmed the investments in these areas. Integrated exploitation and cascade direct use of the geothermal energy will realize by integrated scheme [2, 4, 6]. This scheme has an environmental benefit by using renewable energies (geothermal energy, solar energy), new technologies (heat pumps) and energy savings (cascade scheme). Cascade scheme should be used to fulfill the thermal energy demand for the selected area in order to get the maximum benefit from geothermal energy and the minimum energy supply from heat pumps: the promotion of energy savings will be in place.

Exploitation of geothermal energy will have a direct impact in the development of the regions, by increasing their per capita income and at the same time ameliorating the standard of living of the people. These investments will be profitable in a short period of time.

2. GEOTHERMAL ENERGY RESOURCES IN ALBANIA

2.1. Methodic

The results of the geothermal studies carried out in Albania are presented in maps and geothermal sections. Temperature maps have been drawning for different levels of up to 3000m depth [3, 5]. Geothermal gradient, heat flow density and geothermal resources maps have also been drawn. The natural springs with thermal waters and the geological structures with high water temperature have also been mapped [1, 3, 5]. The study of the possibility of exploitation of abandoned deep oil wells as "Vertical Earth Heat Probes" has already begun.

2.2 Geothermal Features

The Albanides form an integral part of the southern branch of the Mediterranean Alpine orogen. They are subdivided in two zones: the Internal and the External Albanides. The geology of Albanides creates the premises for the research and exploitation of natural geothermal energetic resources [3, 5].

The greatest heat flow density with a value of 42 $mW \cdot m^{-2}$ is found in the center of the Preadriatic Depression (Fig. 1). In the east of the ophiolitic belt heat flow density reaches values of up to 60 $mW \cdot m^{-2}$.

The temperature at a depth of 100m ranges 6.7 to 18.8°C, in average 16.4°C (Fig. 2) and at a depth of 500m from 21 to 27.7°C.The

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temperature ranges up to 105.8°C at a depth of 6000m. In the central part of the Preadriatic Depression, there are many deep oil wells where the temperature reaches up to 68°C at a depth of 3000m.

The geothermal gradient has the highest value about 18.7 $mK \cdot m^{-1}$ in the center of the Peri Adriatic Depression. Elsewhere the gradient is mostly 15 $mK \cdot m^{-1}$. In the south of the country the geothermal gradient has low values 11.5-13 $mK \cdot m^{-1}$. Towards the northeastern and southeastern regions of Albania, over the ophiolitic belt, the geothermal gradient increases, reaching the value of 23.5 $mK \cdot m^{-1}$.

2.3. Geothermal Areas and Reservoirs

In Albania there are many thermal springs and wells of low enthalpy (Fig. 3, Tab. 1) [1, 3, 5, 8].

Table 1 Thermal water sources and wells in Albania

Type of the source	Location	Temperature, (°C)	Salt, (mg/l)	Yield, l/sec
Natural Spring	Llixha Elbasan, Peshkopi, Krane (Sarande), Langaric (Permet), Shupal (Tiranë), Sarandoporo (Leskovik), Postenan (Leskovik) Tërvoll (Gramsh), Mamurras (Tiranë).	21-60	0.3-26	10-40
Deep wells	Peri Adriatic Depression and in the Kruja tectonic zone	29.3-65.5	1-19.3	0.9-18

Thermal water springs and wells are mainly located near of the regional tectonic fracture zones. Generally the water circulates through carbonatic rocks and sandstones of the anticlines and evaporitic beds at the depth of 800-3000m. The water of these springs contains salt, absorbed gas and organic matter. They are sulfide: methane, iodine-bromium and sulfate types. Thermal sources are located in three geothermal zones (Fig. 3):

- Kruja geothermal zone represents a zone with bigness geothermal resources. Kruja zone has a length of 180 km. Identified resources in carbonate reservoirs are $5.9x10^8$-$5.1x10^9$ GJ,
- Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs.
- Peshkopia gjeotermal zone is located at northeastern area of Albania. Several springs are located with disjunctive tectonics of the gypsum diapir.

3. DIRECTIONS FOR THE EXPLOITATION OF GEOTHERMAL ENERGY OF LOW ENTHALPY IN ALBANIA

The geothermal situation of low enthalpy in Albania offers following directions for the direct use of geothermal energy, which is unused until now. This exploitation must be realized by integrated scheme of geothermal energy, heat pumps and solar energy, and cascade use of this energy [2, 4, 6].

Firstly, space heating and cooling using ground heat by the Borehole Heat Exchanger (BHE), in the shallow (about 100 m depth) boreholes.

Secondly, thermal sources of low enthalpy and of maximal temperature up to 80°C. These are natural sources or wells in a wide territory of Albania, from the South near Albanian-Greek boundary to Northeast districts in Diber Region.

Thermal waters of springs and wells in Albania may be used in several ways:

1. Modern SPA clinics for treatment of different diseases and hotels, with thermal pools, for development of eco-tourism. Such centers may attract a lot of clients not only from Albania, because not only the good curative properties of these waters but also springs are situated in nice places near sea side, mountains or Ohrid Lake. An the present some SPA, with a primitive technology, worked in some geothermal springs and wells in Albania.
2. The hot water can be used also for heating of hotels, clinics and tourist centers, as well as for the preparation of sanitary hot water used there. Near these medical and tourist centers it is possible to built the greenhouses for flowers and vegetables, and aquaculture installations.
3. From thermal mineral waters it is possible to extract very useful chemical microelements as iodine, bromine, chlorine etc. and other natural salts, so necessary for preparation of creams for the treatment of many skin diseases as well as for beauty care products. From these waters it is possible to extract sulphidric and carbonic gas. It is possible to built installations for processing of mineral waters.

Consequently, the sources of low enthalpy geothermal energy in Albania, which are at the same time the sources of multi-element mineral waters, they represent the basis for a successful use of modern technologies for a *complex and cascade exploitation* of this energy, achieving a economical effectiveness. Such developments are useful also for the creation of new working places and improvement of the level of life for local communities near thermal sources.

Thirdly, the use of deep doublet abandoned oil and gas wells and single wells for geothermal energy, in the form of a "Vertical Earth Heat Probe". The geothermal gradient of the Albanian Sedimentary Basin has average values of about 18.7 $mK \cdot m^{-1}$. At 2 000 m depth the temperature reaches a value of about 48°C. In these single abandoned wells a closed circuit water system can be installed. Near of these wells can be build greenhouses.

Actually in Albania the study of the possibilities of exploitation of the geothermal energy has begun. Based on the above analysis, for the best area selected, a Feasibility Study will be performed to analyze three components: energy supply, environmental impact and financial aspects, and to suggest the best solution of the innovative geothermal energy utilization technology applications in that area.

4. ALBANIAN GEOTHERMAL ENERGY MARKET

Successfully of the direct use of the environmental friendly geothermal energy has necessity for a market analyze. Objectives of market study are as following:

- Evaluation of present status of geothermal development in Europe, particularly in Balkan countries, regarding promotion activities, results, application, barriers for market penetration, legal and financial framework, etc.
- Comparison of present status between the different Albanian regions.
- Identification of the attitude and feelings (awareness, knowledge, preference, etc.) for the target groups towards geothermal energy.
- Identification of the attitude and feelings of the target groups towards environmental aspects of geothermal energy.
- Evaluation of the outcome of promotion methods adopted by EU and national institutions.
- Formulation of proposals for effective promotion strategies for geothermal energy in Albania.

4.1. Space heating and cooling

The energy crisis prevailing in the Albania, the increased demand in energy for heating and cooling of premises. Actually, the electric energy consummation for heating is 1 375 GWh/year, or 23.8 % of the total electric energy production in Albania [8]. The situation becomes more problematic because the use of natural gas for heating emits large quantities of CO_2 in the atmosphere.

Direct use of the ground heat by Borehole heat Exchanger-Geothermal Heat Pump represents a modern system for space heating and cooling (Lund J. 2005, Rybach L. and Sanner B. 2005, Sanner B. 2004). Two types of shallow heat sources exist: ground heat and underground waters heat. Consequently two kind of technology is possible to applied:

Firstly, ground-source and Borehole heat Exchanger-Geothermal Heat Pump or ground-couplet (closed loop),

Secondly: underground water system – Geothermal Heat Pump (open loop).

In order to make use of this renewable geothermal energy and environmental friendly ground heat for space heating and cooling in Albania, we have introduced the idea of building a demonstrative installation for heating and cooling purposes in Tirana [4]. It will contribute in solving the problematic issue of heating and cooling of premises in Albania.

Heat quantity, temperature at Earth surface, and geothermal gradient in shallow geological section, are conditioned by geographical location, geomorphological conditions, ground and bedrocks lithology, specific heat and humidity, season and weather. According to the multi annual meteorological surveys result that in average is 140,000 calory.cm^{-2} heat from solar radiation of the ground during the summer at the plane areas of the Albania. Heat quantity reaches 120,000 calory.cm^{-2} at noertheaster mountains regions [7].

The distribution of the temperature at the depth 100m is presented in Fig. 2. Temperature in subsurface ground at littoral area varies from 16.60^{O}C to 18.80 ^{O}C, averagely 17.80 ^{O}C. In the western plane-hilly area the temperatures have a minimal values 17.15 ^{O}C to 18.41 ^{O}C, and average. In hilly-mountains regions the temperature is 6.70 ^{O}C up to 18.60 ^{O}C, with average temperature is 14.75 ^{O}C. In the Tirana field, the temperature is 15.5 ^{o}C, up to logging depth 31 m, in the Quaternary deposits (Fig. 4) [5]. Ground geothermal energy has heated the underground water reservoir. Tirana underground water basin have a temperatures 14-15 ^{o}C for the Quaternary gravel layer water and 15-16^{o}C for Quaternary sandstone layers waters. Consequently, concluded that water of the underground basin present a heat source for the geothermal pumps.

4.2. Consumers for geothermal energy & thermal water (SPA heating, tourism, drinking water, aquaculture, agriculture)

At the present, some SPA, with a primitive technology, worked in geothermal springs and wells in Albania: Lixha Elbasani, Bilaj Balneological Center (Ishmi 1/b well), Peshkopia (Diber district) SPA, Sarandaporo (Leskovik Disrict) SPA, Langarica-Ura Kadiut (Permeti District).

The oldest and important is Elbasani Llixha SPA, which located about 10 km south of Elbasani city and 61 km in southeast of Tirana The proximity with highways creates great possibilities for Elbasani Lixha SPA to be a nice place. This area may be frequented by a large number of people from different Balkan and European countries. These thermal springs from about 2000 are known years ago. According to historic data, in Elbasani Llixha thermal springs there has been an inn, near of the old road "Via Egnatia" that has passed from Durresi to Constantinople. There are seven spring groups that extend like a belt with 320^{o} azimuth. Surface water temperature is about 60^{o}C and yield in total 15 l/sec. Springs have constant hot water yield and temperature for a long period of time. These data are evidence of a stable thermo-hydrodinamic reservoir regime.

Actually, is not a thermal waters law in Albania, last years has been prepared the draft of the law.

All seven groups of the springs in Llixha Elbasani and Kozani-8 well geothermal area will have the possibilities for modern complex exploitation. The beautiful landscape of Elbasani Lixha area will be not only for medical treatment but also as tourist place. This area located near of the very know Ohrid Lake pearl or mountains Gjinari, with their fantastic forests and nice climate. Ishmi 1/b geothermal well is located in beautiful Tirana field, near of "Mother Theresa" Rinasi (Tirana) Airport, near of the Adriatic coastline and Kruja - Skendergeg Mountain. There are all the possibilities for the echo-tourism development: thermal water, Ishmi beach at the Adreatic Sea , and mountain's area.

Benja and Sarandaporo thermal water areas and Postenani steam springs are located near of the beautiful Vjosa River valley. Peshkopia geothermal springs area is located near of the Korrabi Mountain, higher mountain in Albania (2753m). The beautiful landscape of Vjosa valley, near Albanian-Greek border, and Peshkopia area near of the Debar region in Macedonia, will be not a thermal water bearing place for medical treatment but also as tourist place.

4.3. Geological risk, financial possibilities to cover geological risk

No geological and financial risk for the exploitation of thermal water of geothermal springs and wells in Albania.

4.4. Traffic connections: roads, railways, navigation, and possibilities for transport of heavy goods.

The Ishmi-1/b well is located in Ishmi area and represents the northernmost geothermal well of the Kruja geothermal area. It is located in 20 kilometers NW of Tirana (near of "Mother Theresa" Tirana Airport). By national road communication, Ishmi 1/b well is connected with Tirana, Tirana Airport, Durresi and Shkodra cities.

Kozani-8 well is located 35 kilometers southeast of Tirana, on hill's area. Well connected by 1.7 km road with Tirana-Elbasani national road, and highway "Corridor 8" Durresi-Elbasan-Skopje. One km from Kozani 8 well located Saint George Vladimir Monastery.

Elbasani Llixha SPA is located about 12 km south of Elbasani city and 61 km in south-east of Tirana, in the Central part of Albania. By national road communication, Llixha area is connected with Elbasani and Tirana. Only 10 km will be from the highway Durresi-Skopje- Sofia- Istanbul, which is projected for construction in the future and nominated as No. 8 European Corridor.

Peshkopia geothermal springs are connected with Tirana by national road (182 km).

Benja-Langarica, Postenani and Sarandaporo geothermal springs areas are located near of the national road Tirana-Permeti (about 217 km)-Konitza (Greece).

5. THE AIMS AND OBJECTIVES OF THE PLATFORM FOR DIRECT USE OF THERMAL WATERS OF LOW ENTHALPY

5.1. The aims of the platform

To examine, demonstrate and disseminate the positive technical and financial aspects of transfer and utilization of innovative geothermal energy technologies in Albania, which will have a direct impact in the development of the regions by increasing their per capita income and at the same time ameliorating the standard of living of the people.

5.2. Objectives:

Integrated exploitation and cascade direct use of the geothermal energy has proposed. The objectives of the platform:

- Country Geothermal Energy and mineral water resources evaluation.
- In-situ detailed investigation of the pre-selected zones with high energy potential and consumers geothermal source, where will installed demonstrative unit.

Among others this task will be concerned with intentions of users-thermal load inspections, initial energy balance analyses, thermal characteristics of individual users, technical geothermal data collection, and examination of existing technology. It is necessary to select the thermal applications, which correspond to the local needs. The following will be defined:

a) In situ consideration of geothermal physical-chemical parameters and potential.
b) Thermal load demands for space heating for each end-user of geothermal sources: dwellings, geothermal SPA, greenhouses, geothermal pools and bathing, aquaculture, mineral waters production, and extraction of the micro-elements and natural salts
c) Energy balance between different end-users,
d) Technologies to be applied
e) Preliminary design of the geothermal energy exploitation system
i) Definition of thermal demands
k) Energy conservation, and
l) Economic evaluation of thermal energy (space heating and hot water production installation cost, life cycle, energy product cost, pay back period). This evaluation must based on actual market prices for equipment, construction etc.

Based on the above analysis, for the best area selected, a feasibility study must performed to analyze three components: energy supply, environmental impact and financial aspects, and to suggest the best solution of the innovative technology of direct use of geothermal energy applications in that area.

Environmental protection and preserving level must improve, to well assist the echo-system protection of thermal and mineral water source areas. Among other subjects this phase will focus mainly on examination of the nature of the geothermal fluid, environmental impact of the geothermal fluids during their utilization and disposition, and selection of the most acceptable environmentally methods for the disposal of the geothermal fluids.

The concrete detailed design for the implementation phase of the Platform necessary to be prepared.

- Task 1. Demonstrative units (pilot plants) will be constructed, monitored and finally demonstrated: SPA, with 30-40 beds, for the medical treatment, heating installation in the buildings, greenhouse for the flower and for the legumes, thermal pool for tourists, installation of equipment for extraction microelements and natural salts.
- These demonstrative units will assist in the promotion of the new innovative technology application. The proposed schemes represent an integrated scheme and cascade scheme for exploitation of geothermal energy geothermal energy, heat pumps and solar energy to fulfill. This scheme has an environmental benefit by using renewable energies. Cascade scheme should be used to fulfill the thermal energy demand for the selected area in order to get the maximum benefit from geothermal energy and the minimum energy supply from heat pumps: the promotion of energy savings will be in place.
- Task 2: A promotion and tourist agency will be organized. This agency will prepare the reclaims and booking of the rooms for Albanian and foreign patients.

6. GATHERING INFORMATION MATERIAL AND KNOWLEDGE DISSEMINATION IT IS VERY IMPORTANT ELEMENT OF UTILIZATION OF GEOTHERMAL ENERGY

Information material concerning the general principles of geothermal application and new technologies will be prepared and gathered: booklet and posters will be published. For further dissemination of the results of this projects will organize days of open conferences, workshops, seminars, TV and radio-emissions, pamphlets, posters, and summer school.

Establishment of communication channels with local users: Local authorities, Market and Technical Chambers, and investors, is programmed.

7. SIGNIFICANCE OF THE PROPOSED PLATFORM AND ITS EXPECTED ACHIEVEMENTS

The proposed platform has great importance for Albania. It creates the scientific knowledge base for evaluation of natural wealth of geothermal energy and mineral waters in Albania. These data will be used to evaluate and select the rich areas in country. In these areas it is possible to start the investment for direct use of geothermal energy. Very important is transfer of new methods for R&D and evaluation of geothermal water resources, modern technologies and unit equipment for thermal waters exploitation in Albania. Technical and organizing base for modern hotel SPA construction will be created. The tourism will be developed. New modern studying technologies must disseminate in scientific and business community of country. Environmental protection and preserving level will be improved, to assist the echo-system protection of thermal and mineral water source areas.

8. CONCLUSIONS

1.Albania has the resources of geothermal energy of low enthalpy, which is possible for integrated and cascade direct use as an alternative energy.

2. Resources of the geothermal energy in Albania are;

a) Natural springs and deep wells with thermal water, of a temperature up to 65.5°C.

b) Heat of subsurface ground, with an average temperature of 16.4°C and depth Earth Heat Flow.

3. Construction of the space-heating system, using shallow borehole heat exchanger (BHE)-Heat Pumps systems present the most important direction of the use of geothermal energy in Albania.

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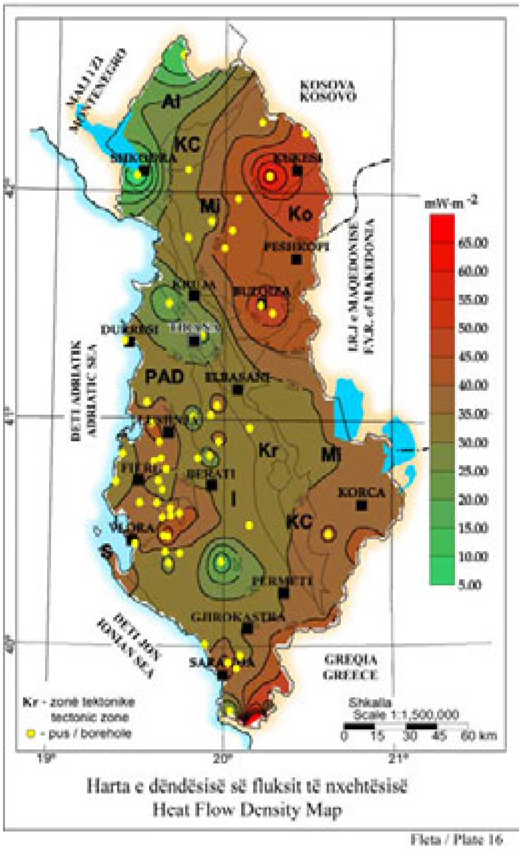


Fig. 1 Heat Flow Density Map of Albania

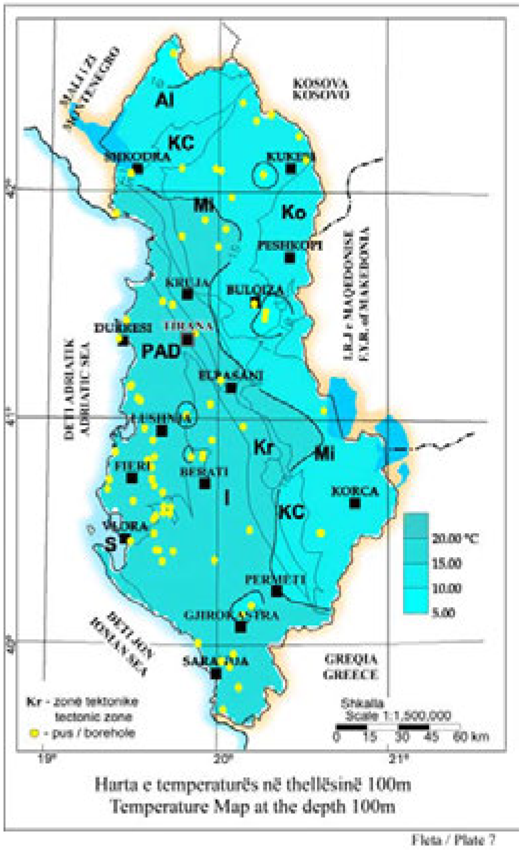


Fig. 2 Temperature Map of Albania, at the depth 100m

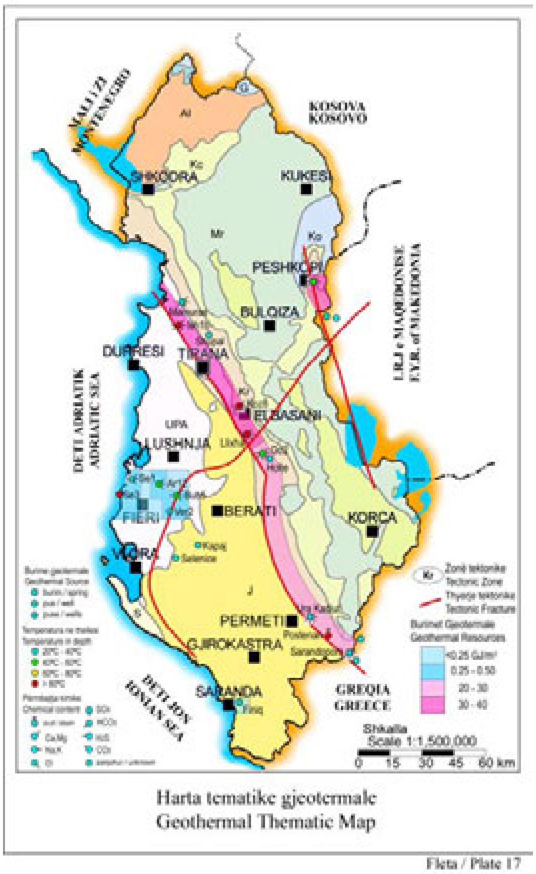


Fig. 3 Geothermal Zones in Albania

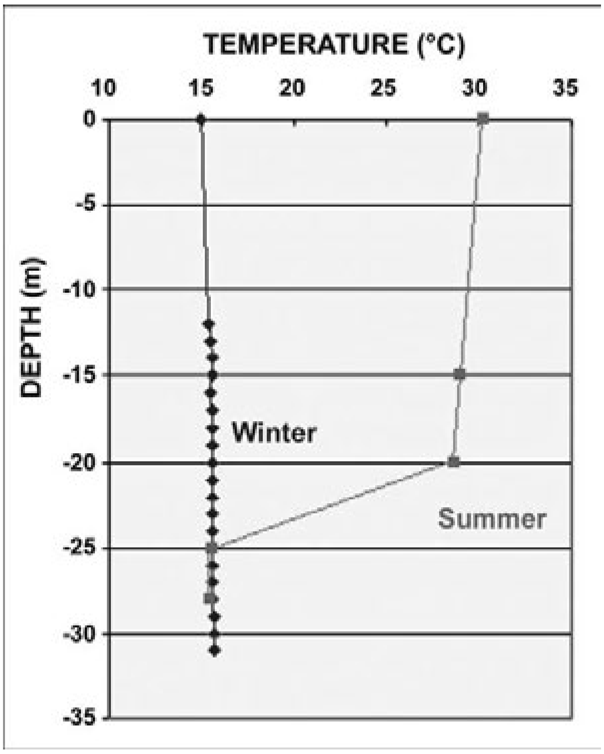


Fig. 4 Thermolog of the Rinasi borehole

Programi i Granteve të Vogla, GEF

Shoqata "Mbrojtja dhe Ruajtja e Ujërave të Embla dhe Bregdetare të Shqipërisë"

ENERGJIA GJEOTERMALE SI BAZË PËR TEKNOLOGJINË MODERNE TË NGROHJES DHE FRESKIMIT TË MJEDISEVE

Workshop, Tiranë 2006

SISTEMET MODERNE TË NGROHJES DHE FRESKIMIT TË GODINAVE ME ENERGJINË GJEOTERMALE.

Prof. Dr. Alfred Frashëri

1. Nxehtësia e tokës është energji alternative, miqësore me mjedisin, që duhet shfrytëzuar edhe në Shqipëri

Shfrytëzimi i energjive të rinovueshme është prirja e sotme në vëndet e përparuara të botës, për disa arësye: së pari per te plotësuar kërkesat energjetike qe nuk plotësohen nga resurset energjetike të lëndëve djegëse dhe së dyti, janë energji miqësore për mjedisin. Gjatë shfrytëzimit të energjive të rinovueshme nuk çlirohen gazra që krijojnë efektin serë dhe nuk kanë impakte negativetë mëdha mbi mjedisin, madje shpesh herë ndikojnë për përmirësimin e ekosistemeve.

Prandaj është e kuptueshme që zhvillimet energjetike bashkohore karakterizohen sot, në shtetet ë përparuara të Komunitetit Evropian, në SHBA, në Japoni etj., nga shfrytëzimi gjithënjë e më shumë e energjive të rinovueshme si e ujit, e Diellit, e erës, gjeotermale dhe e biomasës. Toka është një planet i nxehtë. Llava e vullkaneve dhe ujërat e nxehta të shumë burimeve janë dëshmimtarët më të mirë të nxehtësisë së Tokës në thellësi. Shfrytëzimi i drejtpërdrejtë i energjisë gjeotermale zë një vend të

rëndësishëm në bilancin energjetik pas energjisë hidrike. Energjia gjeotermale është energji alternative, miqësore me mjedisin, me efekte shrytëzimi integral dhe kaskadë. Ajo shfrytëzohet edhe drejtpërsë drejti në shumë fusha të veprimtarisë jetësore dhe ekonomike. Në nivel botëror, në vitin 2005 kapaciteti i instaluar dhe energjia gjeotermale e shfrytëzuar drejtpërdrejtë, ka patur këtë strukturë (Lund J., World Geothermal Congress 2005):

Përdorimi	Kapaciteti i instaluar në MWt	Energjia e përdorur në TJ/vit
Pompa gjeotermale nxehtësie për ngrohje dhe freskim të godinave	15,723	86,673
Banja termale	4,911	75,289
Ngrohje godinave	4,158	52,868
Sera	1,348	19,607
Akuakulture	616	1-,969
Përdorime industriale	489	11,068
Gatim	338	1,885
Tharje produktesh bujqësore	157	2,013
Të tjera	86	1,045
TOTAL	**27,825**	261,418

Potenciali real i energjisë gjeotermale mund dhe duhet të shfrytëzohet për qëllime ekonomike edhe në Shqipëri.

Albanidet, që përfaqësojnë strukturat gjeologjike në territorin shqiptar, kanë fluks gjeotermal të aftë për tu vënë në shfrytëzim. Në Shqipëri ka edhe shumë burime dhe puse të ujrave termale, të energjisë gjeotermike të entalpisë së ulët. Në Shqipëri ka edhe shumë burime dhe puse, të cilët japin ujëra me temperaturë deri 65.5 °C dhe me debite deri 15 l/sek. Këto janë burim i energjisë së rinovueshme, që duhet te fillojë të shfrytëzohet në Shqipëri.

Për të filluar shfrytëzimin e kësaj energjie në Shqipëri, duhet:

Së pari të sensibilizohet opinioni publik, administrata publike dhe investitorët shqiptarë per efektivitetin e saj.

Së dyti, aktualisht në Shqipëri ekzistojnë studime gjeotermike, hidrogjeologjike, hidrokimike dhe biologjike të ujërave termale, si edhe studime mjekësore. Fakulteti i Gjeologjisë dhe i Minierave, Universiteti Politeknik i Tiranës, botoi në muajin tetor 2004 "ATLASI I BURIMEVE TË ENERGJISË GJEOTERMALE NË SHQIPËRI", në kuadrin e Programit Kombëtar për Kërkim e Zhvillim "Pasurite Natyrore", 2003-2005.

Në Atlas argumentohet se strukturat gjeologjike të Shqipërisë janë bartëse të rezervave të mëdha të energjisë gjeotermale të entalpisë së ulët (Fig. 1, 2). Mbështetur në kapacitetet e energjisë gjeotermale në Shqipëri, si edhe në përvojën boterore të shfrytëzimit të kësaj energjie me teknologji moderne dhe me efektivitet ekonomik të lartë, tërheqim vëmendjen e komunitetit të biznesit shqiptar se ka mundësi të krijoje bisnese të reja fitim prurëse në disa drejtime:

1. **Shfrytëzimi integral dhe kaskadë** i nxehtësisë së ujërave gjeotermale. Ky shfrytëzim i ujërave termale të burimeve ose të puseve lehtësohet nga fakti se ato përgjithësisht ndodhen në zona të zhvilluara nga ana urbane në Shqipëri. Deri tani vetëm disa ujëra të burimeve termale, si ato të Lixhave në Elbasan, Në Bilaj të Fushë Krujës, të Peshkopisë etj shfrytëzohen vetëm për kurimin e sëmundjeve të ndryshme. Por ky shfrytëzim i kësaj energjie në mënyrë primitive, si koncept dhe si mundësi zhvillimi. Këto ujëra mund të shfrytëzohen me efektivitet të lartë ekonimik për:
2.

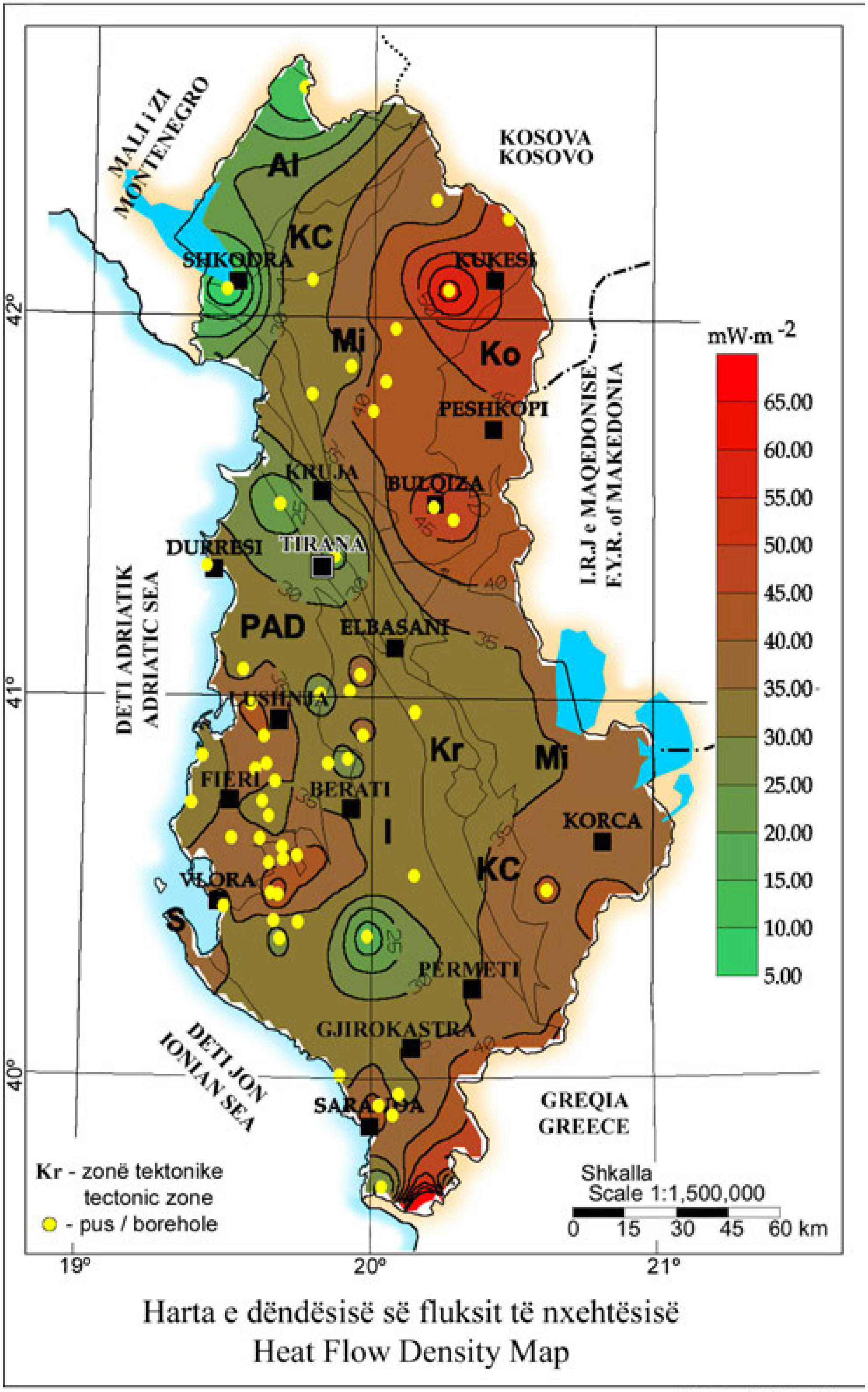
a) Ekoturizmin gjeotermal. Mjafton të përmëndim se në Itali, qëndrat komplekse gjeotermale i vizitojnë rreth 2.5 milion turistë/vit. Mund të ndërtohen hotele me pishina me ujë të ngrohtë, me sauna, me salla e fusha sportive, me lokale argëtimi, etj.

b) Klinika mjekësore moderne, për të tërhequr edhe paciente të huaj, që duan të shfrytëzojnë vetitë e rralla kuruese të shumë ujërave termave të vendit tonë.

c) Ngrohjen e serave dhe zhvillimin e akuaulturës (rritje rasati të peshve dekorative dhe të rrallë, si edhe të algave me të cilat prodhohen pomadat më të shtrenjta për shumë sëmundje dhe kozmetike.

d) Nxjerrje e kripërave dhe e mikroelementeve të dobishëm.

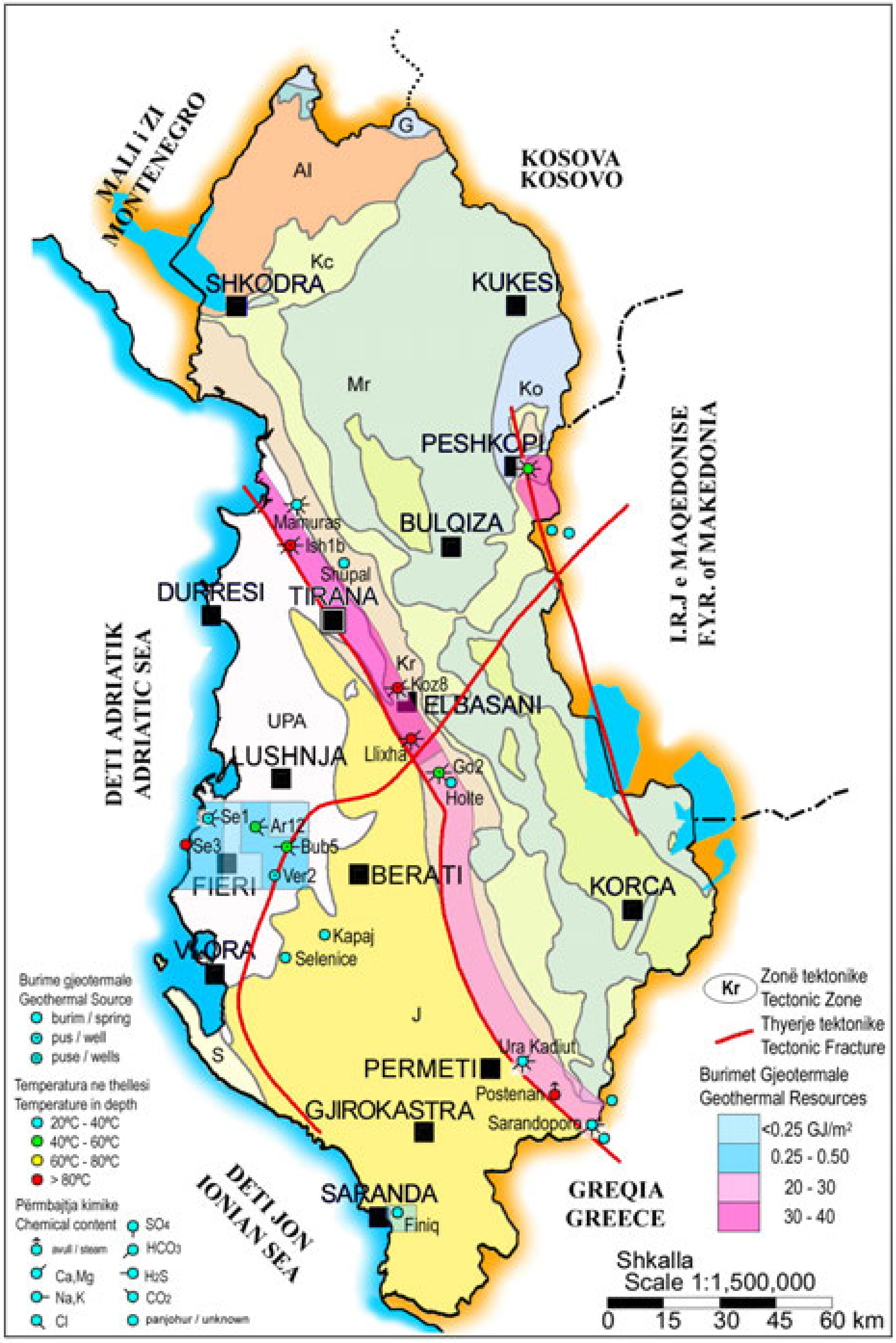
e)Industrializim i ujërave minerale të veçantë.



Harta e dëndësisë së fluksit të nxehtësisë
Heat Flow Density Map

Fleta / Plate 16

Fig. 1



Harta tematike gjeotermale
Geothermal Thematic Map

Fleta / Plate 17

Fig. 2

Foto 1. Llixhat e Elbasanit

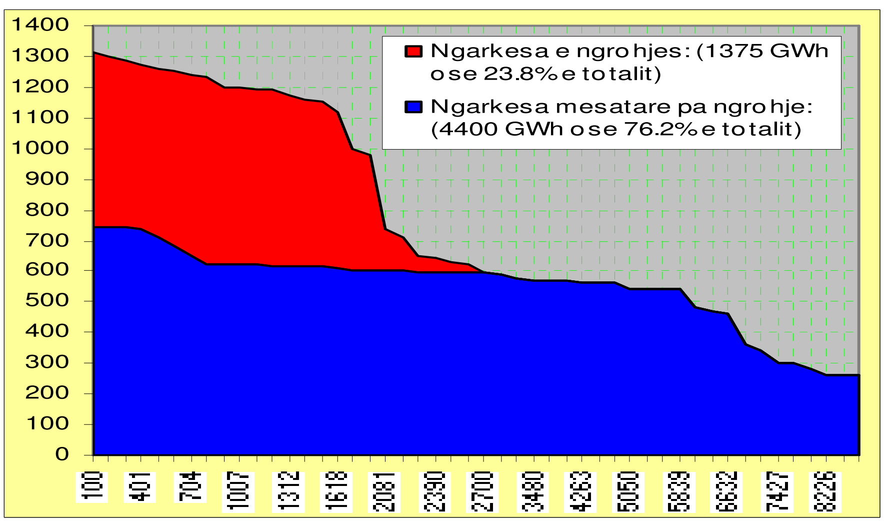
Foto 2. Pusi gjeotermal Kozani-8

Foto 3. Burimet gjetemale të Bënjës, Përmet

Foto 4. Përroi i Banjës, Peshkopi

2. Ngrohja dhe freskimi i banesave me sistemin moderne *pus-këmbyes vertikal nxehtësie-pompë gjeotermale nxehtësie* (BHEGHP). Rëndom, kur bëhet fjalë për energjinë gjeotermale, njerëzit nënkuptojnë vetëm ujërat e ngrohta të burimeve. Kjo është një pjesë e të vërtetës. Por këto ujëra janë zakonisht të rrallë dhe të pakët. Ajo që ka kudo dhe në sasi të mëdha është nxehtësia e shtresave të tokës që nga pjesët pranësipërfaqësore e deri në thellësi të mëdha. Kësisoj, burimi kryesor i energjisë gjeotermale është nxehtësia e këtyre shtresave. Ky duhet të jetë drejtimi kryesor i përdorimit të energjisë gjeotermale është shfrytëzimi i nxehtësisë së shtresave të Tokës Këto sisteme, për të njëjtën kapacitet ngrohës ose freskues, duke shfrytëzuar energjinë gjeotermale, konsumojnë mesatarisht mbi 3 herë më pak energji elektrike, në krahasim me kondicionerët me pompa nxehtesie ajër-ajër, që përdoren sot në vendin tonë, ose ngrohja me këto sisteme është mbi katër herë më të lirë sesa ngrohja me kaldajë me naftë.

Kriza energjetike e vendit, kërkesa gjithnjë e në rritje të energjisë për ngrohjen dhe freskimin e banesave, që në vitin 1999 zinte 23.8% të totalit të energjisë elektrike të prodhuar në vend dhe sot është akoma më tepër, si edhe shkuarja qoftë edhe gradualisht drejt zbatimit të normave europiane për ngrohjen e banesave, për të lënë mprapa ngrohjen vetëm të një dhome nga shqipëtarët në shekujt e varfërisë së tyre, na nxitën të mendojmë për të kontribuar në zgjidhjen e këtij problemi. Çështja bëhet akoma më problemore me përdorimin e naftës e gazit për ngrohje, të cilat veç të tjerash emetojnë në atmosferë sasi të mëdha gazi CO_2.



Kurba e vazhdueshmerisë vjetore të ngarkesës elektrike pa ngrohje me ngrohjen për vitin 1999 (Energjia elektrike totale e furnizuar 5775 GWh), (Agencia Kombëtare e Energjisë).

Ngrohja e godinave publike dhe shtëpive të banimit, si edhe serave me anën e nxehtësisë së shtresave pranësipërfaqësore të tokës është një nga drejtimet aktuale që po përjeton një bum të madh në vendet e Evropës dhe në SH.B.A., Kanada, Japoni etj.

Për këtë qëllim, përdoret Sistemi Këmbyes Nxehtësie-Pus (KNP)-Pompë Gjeotermale Nxehtësie (PGjN), i cili shfytëzon burimet vendore të energjisë, siç është nxehtësia e shtresave pranësipërfaqësore, për ngrohjen e banesave.

Burime nxehtësije mund të jenë:

a) Shtresat pranësipërfaqësore deri në thellësinë 100-150 m.

b) Uji nëntokësor, i ngrohur nga nxehtësia e shtresave.

c) Uji i liqeneve dhe i deteve

Nxehtësia nga shtresat e tokës merret me anën e këmbyesve të nxehtësisë, të disa tipave. Një këmbyes vertikal i nxehtësisë (Fig. 3), koaksial ose në formë U-je, instalohet në shpime 30-150 m të thellë. Fluidi që qarkullon nëpër këtë këmbyes nxjerr nxehtësinë nga shtresat e Tokës. Këto sisteme këmbyesish nxehtësie emërtohen ***me qark të mbyllur.*** Në Shqipëri, ku këto shtresa kanë temperaturë 5-20°C në këmbyes mund të qarkullojë ujë, sepse nuk ka rrezik ngrirje të tij. Këmbyes të shumfishtë, të instaluar në bateri pushesh përdoren për të ngrohur godina të mëdha ose blok godinash publike (Fig. 4)..

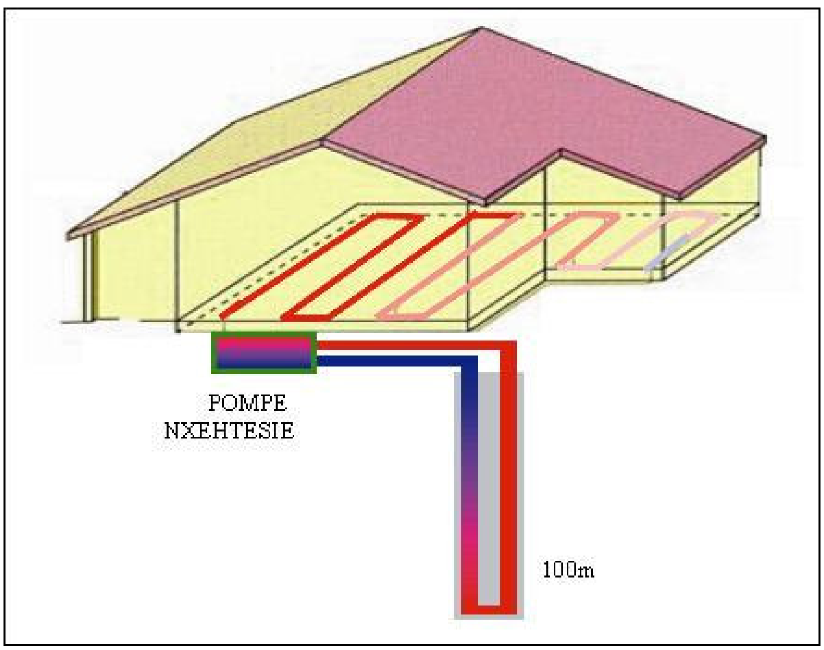


Fig. 3. Këmbyes vertikal nxehtësie në pus 100 m të thellë.

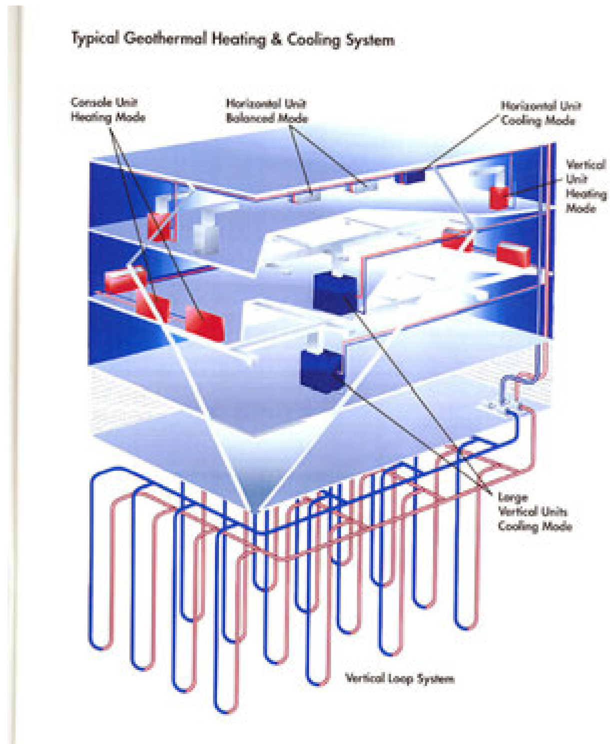


Fig. 4. Bateri pusesh për këmbyesit vertikal të nxehtësisë.

Në zona ku përreth godinës ka tokë, mund të përdoret këmbyes nxehtësie i vendosur horizontalisht, në transhe 1-2-1.8m të thellë (Fig. 5), i cili mund të ketë forma nga më të ndryshmet. Natyrisht, efektiviteti i këtyre këmbyesve të nxehtësisë, sepse në to ka ndikim të madh ndryshimi i klimës.

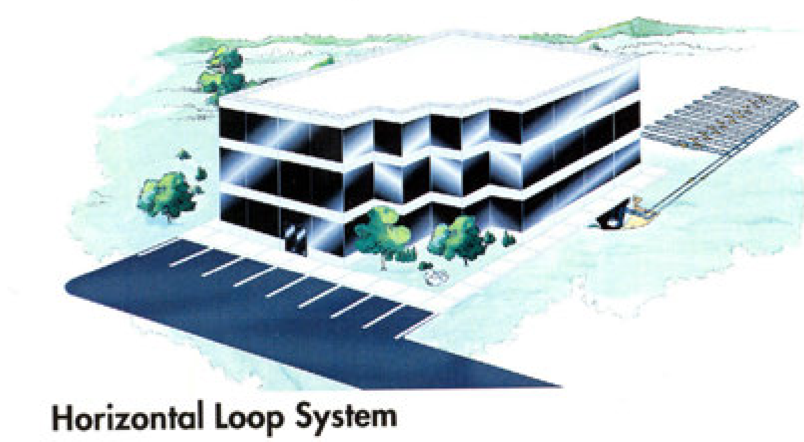
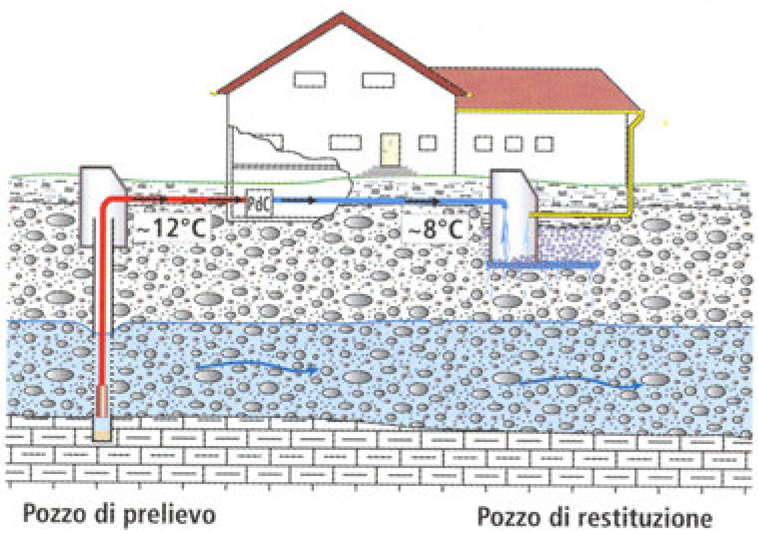


Fig. 5 Këmbyes horizontal nxehtësie i thjeshte

Kur shfrytëzohet nxehtësia e ujërave nëntokësore ose e liqeneve e deteve, sistemet emërtohen ***me qark të hapur*** (Fig. 6). Nga nëntoka ose rezervuari merret uji, i cili dërgohet drejt përse drejti në pompën e nxehtësisë ujë-ujë. Kur merret uji i detit, për të evituar korrozionin, uji i detit futet në një këmbyes nxehtësie. Pasi kalon në pompën e nxehtësisë ose në këmbyesin e nxehtësisë uji i detit, ai injektohet përsëri në shtresat nëntokësore, ose rikthehet në rezervuarin e ujit.



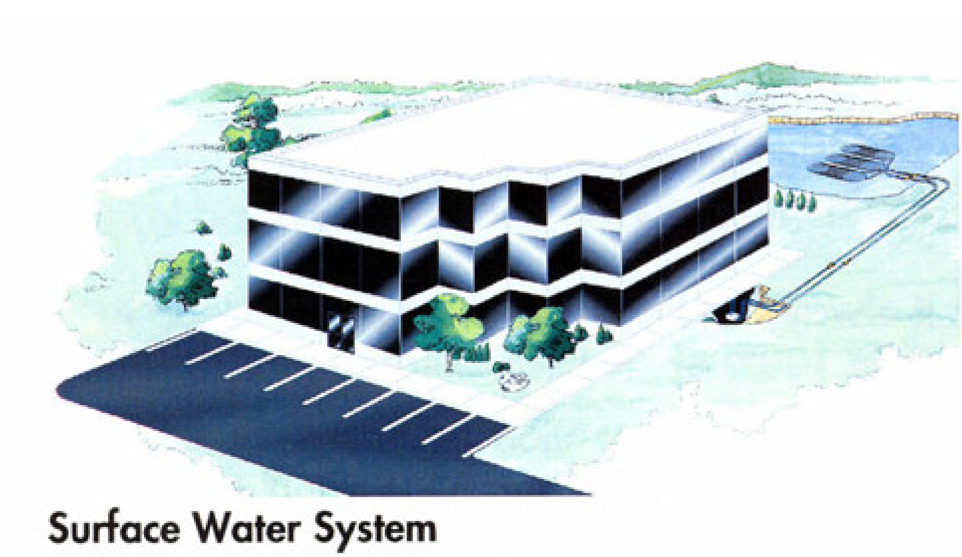


Fig. 6. Sistemi me qark të hapur: a) Pus- Pompë gjeotermale nxehtësie; b) Liqen-Pompë gjeotermale nxehtësie për ngrohjen e banesave dhe te serave.c) Konstruksion i pusit (b).

Aktualisht këto janë sistemet më moderne, me efektivitetin ekonomik më të lartë dhe konsumin më të vogël të energjisë elektrike, me teknologji më të përparuar miqësore me mjedisin dhe po bëhen gjithënjë e më shumë më popullore.

Në 26 shtete në Europë dhe në SHBA, sipas te dhenave jo te plota per vitin 2005 janë montuar 900 mijë instalime BHE-HP, më fuqi 12 kW sejcila, për ngrohjen dhe freskimin e shtëpive-vila, por ka edhe mijëra instalime më fuqi deri 500-1500 kW për ngrohjen e institucioneve dhe të blloqeve të banesave komunale (Ryback L. et al. World Geothermal Congress 2005). Kapaciteti i instaluar është 15 723 MWt dhe energjia e shfrytëzuar 86 673 TJ/vit (24 200 GWh). Në Gjermani aktualisht ka mbi 40 mijë instalime. Në vitin 2005 janë instaluar 6799 pompa gjeotermale nxehtësie dhe vetëm 1526 kondicionerë me pompa ajër-ajër. Shëmbull tipik është edhe Zvicra, ku ka 25 000 instalime, me fuqi të pompës nga 19-40 kW, të cilët shfrytëzojnë nxehtësinë e shtresave pranësipërfaqësore të tokës me temperaturë 10^{o}C. Në Austri ka 23 000 instalime, në Suedi 200 000, në Danimarkë 43 000, në Francë 40 000, në USA 600 000 instalime etj (Curtis R. et al. 2005).

Vendi	Fuqia e instaluar MWt	Energjia e dhene GWh/vit	Numbri i instalimeve
Sh.B.A.	6,300	6,300	600,000
Suedi	2,000	8,000	200,000
Gjermani	560	840	40,000
Kanada	435	300	36,000
Zvicër	440	660	25,000
Austri	275	370	23,000

2. Tabloja e energjisë gjeotermale të shtreseva pranë sipërfaqësore në Shqipëri.

Ashtu si kudo, edhe në Shqipëri shtresat pranësipërfaqesore të Tokës kanë nxehtësi. Nga analiza e gjendjes së regjimit gjeotermal të kësaj prerjeje gjeologjike, rezulton se kjo prerje gjeologjike ka energji gjeotermale e niveleve të tilla që lejon të shfrytëzohet nxehtësia e tyre për të ngrohur godinat (Frashëri A. 2004, Frashëri A. etj. 2004, 2003). Kjo energji mund të shfrytëzohet me sukses për ngrohjen e godinave publike (zyra, spitale, bibioteka, shkolla, teatro e kinema, godina aeroporti etj) si edhe

blloqe banesash e vila për banim, duke shfrytëzuar sistemet moderne të ngrohjes Këmbyes Nxehtësie-Pus-Pompë Gjeotermale Nxehtësie.

Sasia e nxehtësisë, temperatura në sipërfaqen e Tokës dhe gradienti gjeotermal i prerjes gjeologjike praën sipërfaqësore kondicionohen nga kushtet e vendndodhjes gjeografike, kushtet gjeomorfologjike (pjerësia e sipërfaqes së Tokës dhe pozicioni i saj në raport me Diellin), litologjia e truallit dhe e shkëmbinjve rrënjësorë, nxehtësia specifike dhe lagështia, stina dhe moti. Sipas vrojtimeve gjeomorfologjike shumëvjeccare rezulton se mesatarisht 140.000 kalori/cm^2 nxehtësi merr trualli nga rrezatimi diellor gjatë verës në trevat fushore në Shqipëri. Sasia e nxehtësisë arrin në 120.000 kalori/cm^2 në rajonet veri-lindore malore (Gjoka L., 1990).

Shpërndarja e fushës termale në territorin shqiptar, në pajtim me vlerat e gradientit gjeotermal, në në pjesën e sipërme pranësipërfaqësore të prerjes gjeolgjike tregon se temperatura në thellësinë 100m ka vlera si mëposhtë vijon (Fig. 7) (Frashëri A. etj. 2004):

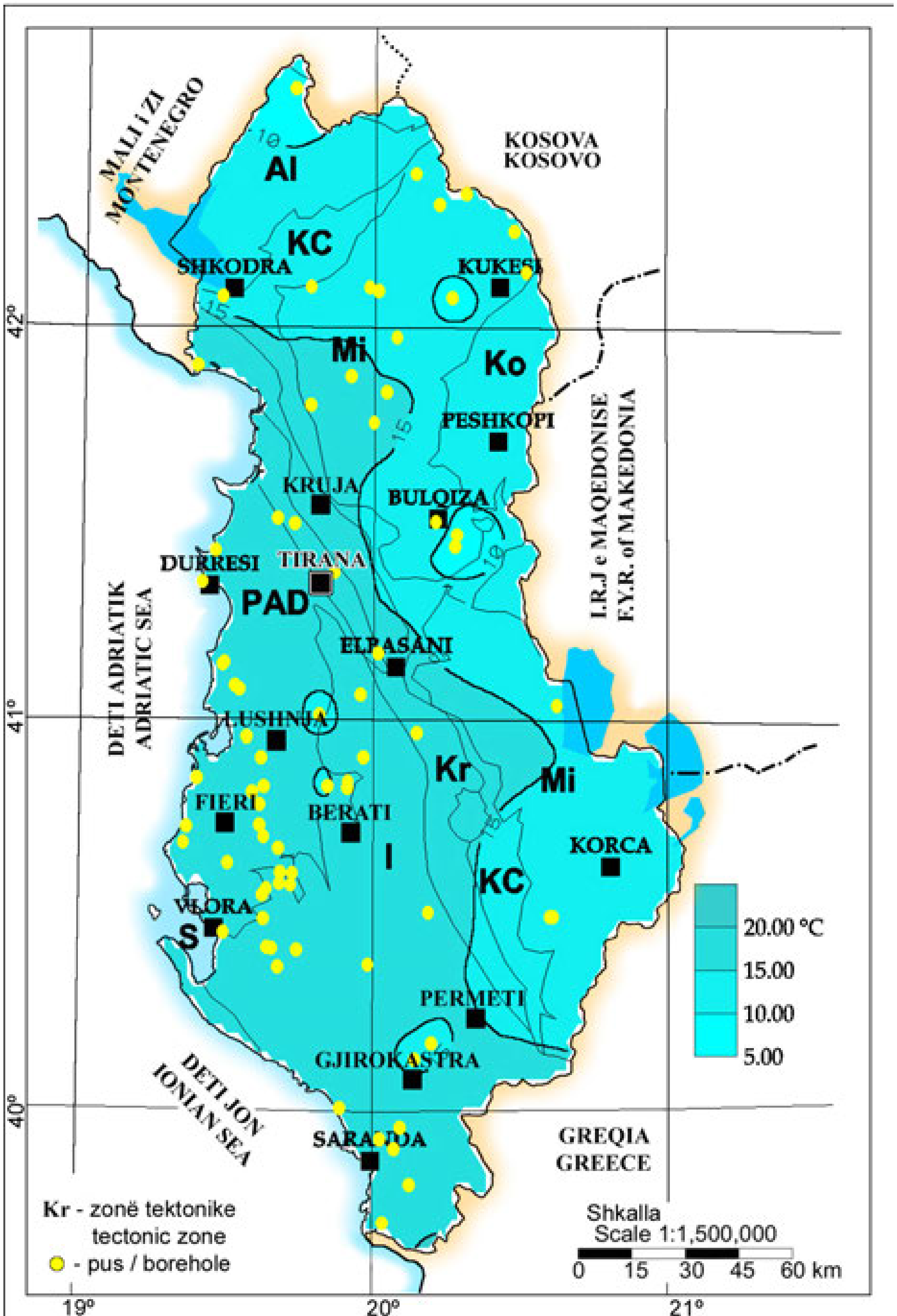
Temperatura në zonën bregdetare:
Minimale 16.6^{o}C
Maksimale 18,8^{o}C
Mesatare 17.8 ^{o}C

Temperatura në zonën perëndimore fushore-kodrinore:
Minimale 17.15^{o}C
Maksimale 18,41^{o}C
Mesatare 18.0 ^{o}C

Temperatura në zonat kodrinore-malore:
Minimale 6.7^{o}C
Maksimale 18,6^{o}C
Mesatare 14.7 ^{o}C

Në fushën e Tiranës (Rinas), temperatura është 15.5^{o}C nga thellësia 20 deri 35m, në depozitimet kuaternare (Fig. 8) (Frashëri A. etj. 2004). Sicc duket nga termograma e pusit në Rinas, nga sipërfaqja e Tokës e deri në thellësinë 20 m, më këtë zonë, temperatura e depozitimeve ndryshon në varësi të stinë dhe përcaktohet nga nxehtësia që Toka merr nga Dielli. Në dimër, temperaturat janë më të ulta, edhe në këtë pjesë të prerjes gjeologjike. Në thellësi më të mëdah, temperatura e depozitrimeve dhe e shkëmbinjve nuk varet nga stinët dhe përcakjtohet nga gradienti gjeotermal normasl i zonës; për rastin e rinasit 15.5^{o}C. Konstatohen ndryshime anësore të temperaturës deri në 0.5^{o}C edhe në distanca deri 500m, në të njëjtën kohë. Këto ndryshime anësore janë kondicionuar nga

litologjia e depozitimeve kuaternare. Është vrojtuar se në rajonet malore të vendit, thellësia e temperaturës që përcaktohet nga rrezatimi diellor arrin deri në 50.



Harta e temperaturës në thellësinë 100m
Temperature Map at the depth 100m

Fleta / Plate 7

Fig. 7

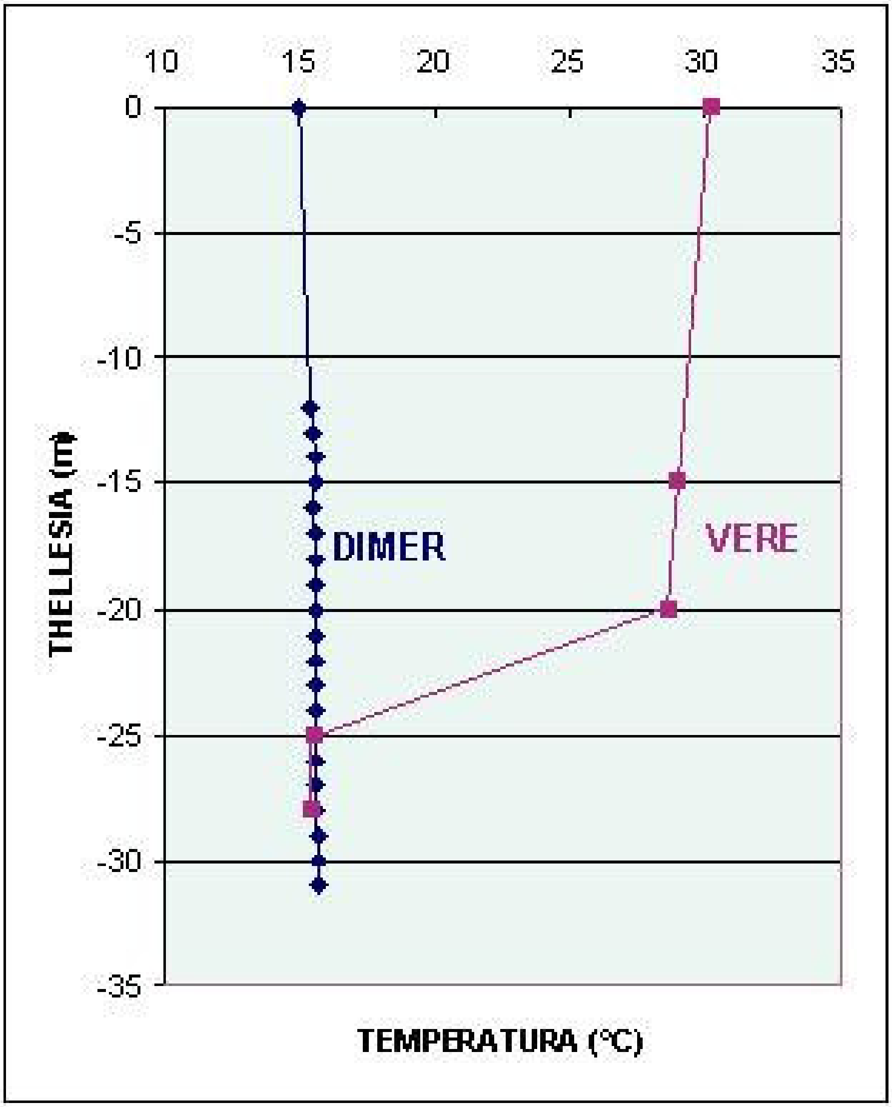


Fig. 8 Termograma e pusit ne fushen e Tiranes (Rinas)

Nxehtësia e shtresave pranë sipërfaqësore të Tokës kanë ngrohur edhe ujërat e rezervuarëve nëntokësorë. Në trevat fushore në perëndim të Shqipërisë, ujërat nëntokësore kanë këto temperatura:

Temperatura e ujit e shtresave zhavorore të kuaternarit është 14-15 °C,
Temperatura e ujit e shtresave ranore të kuaternarit është 15-16 °C,

Për rrjedhoje ujinëntokësor mund të shërbejë si burim nxehtësie për pompat gjeotermale.

3. Vlerësime ekonomike për skemën ngrohëse Pus-Këmbyes vertikal nxehtësie-Pompë gjeotermale nxehtësie

Nga të dhënat e literaturës rezulton se kosto e investimit për sistemet e ngrohjes gjeotermale luhaten 34-216 Euro/m^2 të sipërfaqes së godinës. Kosto më e ulët është në rastet kur si burim nxehtësie shërben uji nëntokësor, për marrjen e të cilit kërkohet të shpohet pus i cekët, në te cilin mund të bëhet edhe ri-injektimi i ujit përsëri në shtresë pasi kalon nëpër pompën gjeotermale. Kosto maksimale del kur burim nxehtësie janë shtresat pranësipërfaqësore dhe pVr tV nxjerrë nxehtësinë kërkohet të shp;ohen puse deri 100m të thellë për të vendosur këmbyesin vertikal të nmxehtësisë. E krahasuar kjo kosto me atë të sistemeve me kaldajë, rezulton se ajo është rreth 135.7% më e madhe.

Sistemet këmbyes nxehtësie-Pus-Pompë Gjeotermale Nxehtësie (KN-P-PGjN) kanë marrë këtë zhvillim megjithesë kanë kosto ndërtimi 30-40 % më të lartë se kosto e sistemeve ngrohëse konvencionale më boiler nafte. Ka disa arsye për këtë:

1) **Konsiderata ekonomike**. Aktualisht, kosto e instalimit te KN-P-PGjN është më e madhe sesa e instalimeve konvencionale me karburant. Megjithë këtë kosto vjetore e "karburantit" te sistemit KN-P-PGjN (energjia elektrike për pompën termike dhe pompën e qarkullimit) janë në mënyrë të konsiderueshme shumë më të ulta sesa karburanti i një ngrohësi konvencional me naftë ose gas. Për koeficient performance KP = 3.5, kursehet deri 71% e energjisë elektrike. Kështu, koha e kthimit të shpenzimeve të KNP është më e shkurtër se koha e punës së vetë sistemit ngrohës.

2) **Konsiderata mjedisore**. KNP-pompë termike është një sistem mjedisor i pastër që nuk emeton gaze CO_2 ("efekti serë"), kështu që evitohet për pronarin e shtëpisë pagesa e taksës për emisionin e gazeve CO_2, e cila është në diskutim në vendet e Komunitetit Europian.

3) **Mbështetje qeveritare**. Për instalimin e sistemit KN-P-PGjN, qeveria japoneze jep një investim prej 200 USD për çdo kWe të Pompës gjeotermale të Nxehtësisë, duke patur një limit të sipërm 5 200 USD.

Për një vlerësim të plotë po paraqesim disa preventive, me qëllim që të analizohen dy probleme: kosto e instalimit të sistemit dhe shpenzimet për energjinë elektrike ose për konsumin e naftës të sistemeve të ndryshme ngrohëse, sipas çmimeve aktuale në Shqipëri.

Godina: Hotel

Sipërfaqja e përgjithëshme e 3 kateve:	610 m^2
Ngrohja: me kalorifere (radiatorë)	
Kapaciteti për ngrohje	68.5 KW
Periudha e ngrohjes	1170 orë/vit

Sistemi ngrohës, analizohen tre variante:

a) Pus-pompë gjeotermale nxehtësie
b) Kaldaje me naftë
c) Kondicionerë

Kosto e përgjithëshme paraprake e instalimit:

a) Pus-pompë gjeotermale nxehtësie	43.000 Euro
b) Pus-kemb. Vert. nxehtesie-pompe gjeo. nxeht.	68.461 Euro
c) Kaldaje me naftë	27.000 Euro
d) Kondicionerë, tip "General"	15.600 Euro

Kosto paraprake e instalimit për metër katror të sipërfaqes:

e) Pus-pompë gjeotermale nxehtësie	71,66 Euro/m^2
f) Pus-kemb. Vert. nxehtesie-pompe gjeo. nxeht.	112,63 Euro/m^2
g) Kaldaje me naftë	44,26 Euro/m^2
h) Kondicionerë ajër-ajër, tip "General"	26,00 Euro/m^2

Kosto paraprake vjetore operative e konsumit të energjisë elektrike ose lëndës djegëse gjatë 1170 orëve, për të vënë në punë sistemin ngrohës:

a) Pus-pompë gjeotermale nxehtësie	33.304 kW	3.384 Euro
i) Pus-kem. V. nxeh.-pom. gjeo. nxe.	33.304 kW	3.384 Euro
b) Kaldajë me naftë	2.282 Lit. naft.	11.982 Euro
c) Kondicionerë	93.636 kW	9.515 Euro
d) Radiatorë elektrikë	137.700 kW	13.993 Euro

Kosto paraprake totale vjetore për energjinë ngrohëse:

- **Euro/KW**	Viti parë	Viti dytë
a) Pus-pompë gjeotermale nxehtësie	677,14	49,40
b) Pus-kem. V. nxeht.-pompe gjeo. nxehtësie	1.048,83	174,93
c) Kaldajë me naftë	569,08	138,91
d) Kondicionerë	366,79	204,28

- **Euro/m²**

a)	Pus-pompë gjeotermale nxehtësie	76,04	5,55
b)	Pus-kem. V. nxeht.-pompe gj. Nxehtësie	. 117.78	5.55
c)	Kaldajë me naftë	63,90	19,64
d)	Kondicionerë	41,19	15,60

Në figurat 9, 10 paraqiten grafikët e kostos për konsumin e energjisë elektrike ose të naftës, si edhe koston e përgjithëshme të instalimit dhe të konsumit të lëndës së parë gjatë dhjetë vjetëve të punës së instalimeve me sisteme të ndryshme ngrohjeje. Duket qartë se p*eriudha e vetshlyerjes së investimeve për sistemin "pus-pomp*ë *gjeotermale nxeht*ë*sie"* është*:*

* 1 vit. Ajo mbulohet vetëm me shpenzimet që do të bëheshin për naftën e kaldajës
* 5 vjet. Ajo mbulohet vetëm me shpenzimet që do të bëheshin për energjinë elektrike të kondicionereve.

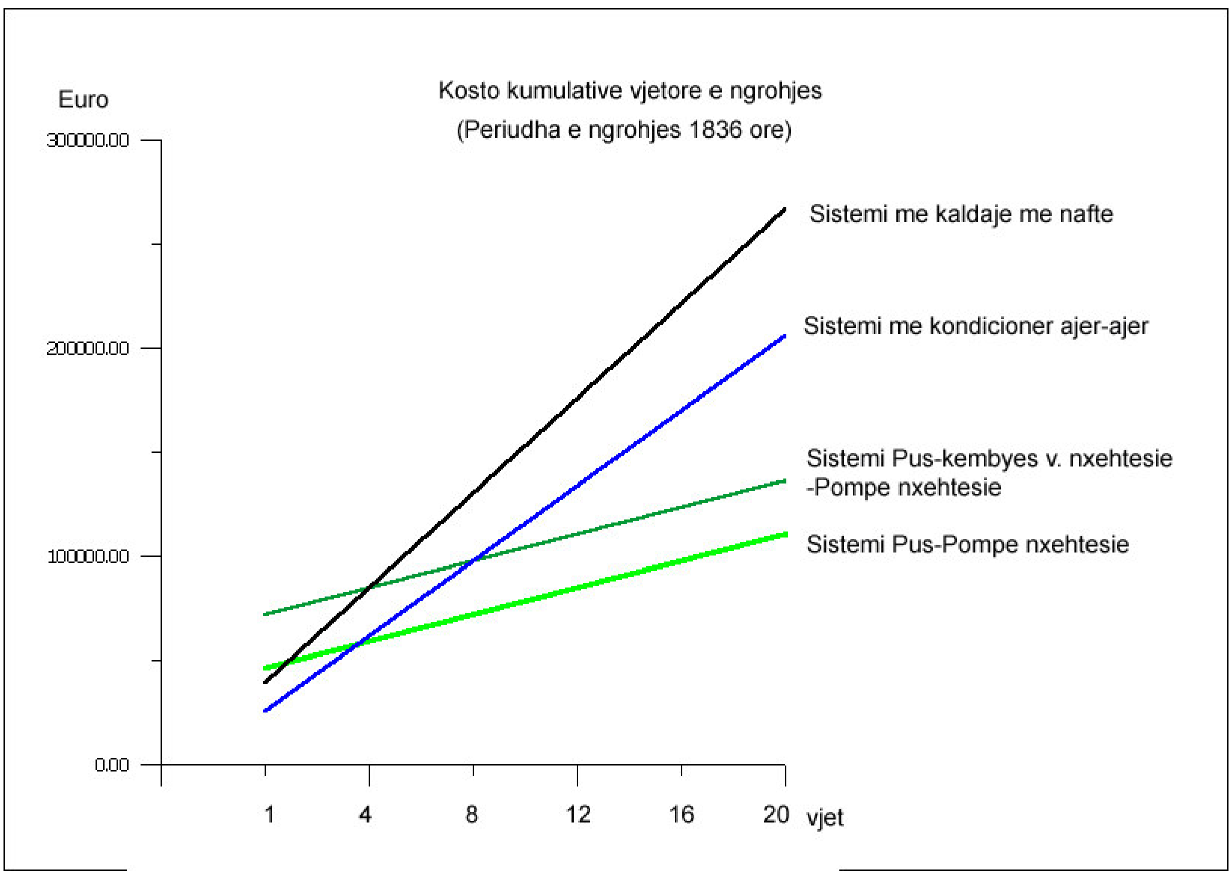


Fig. 9.

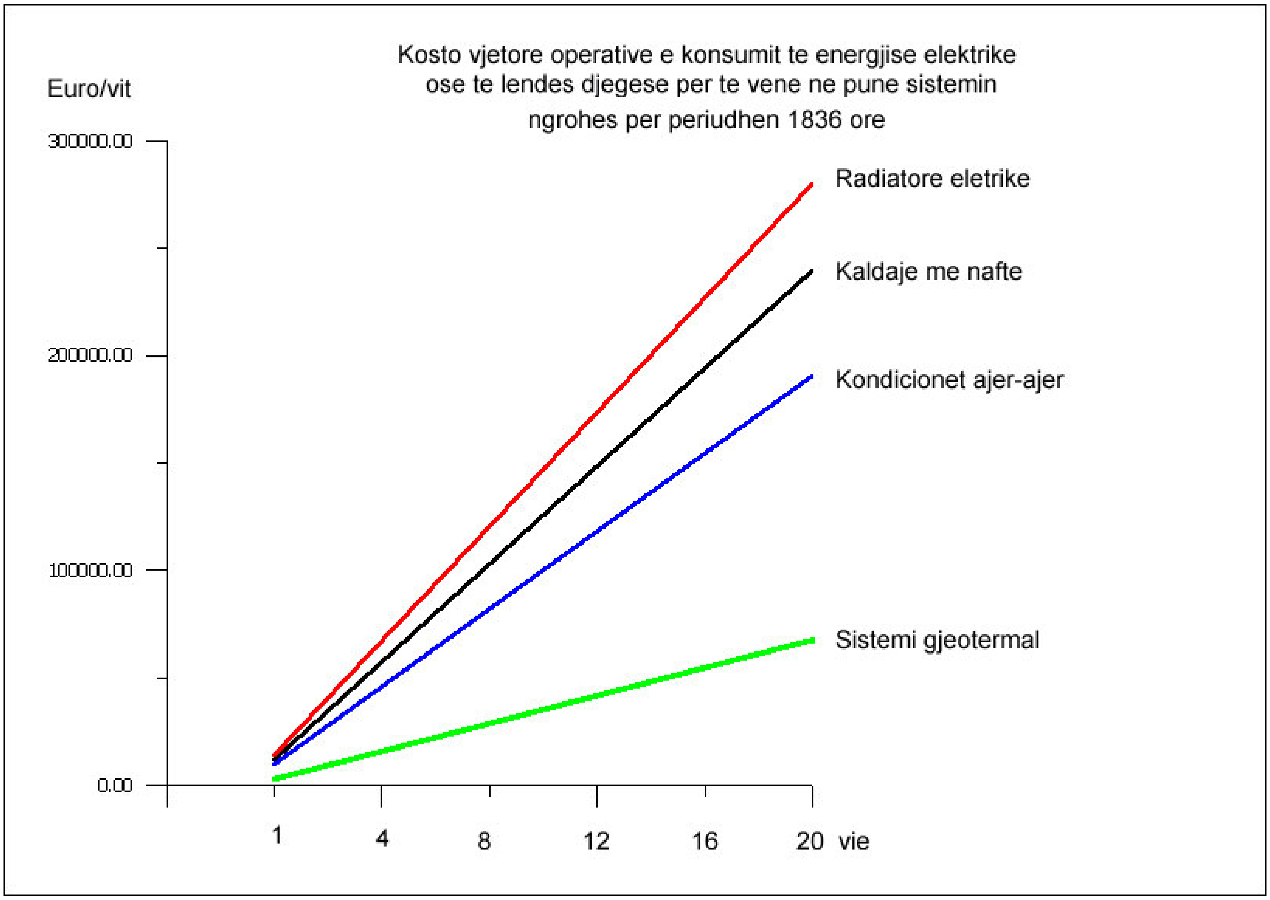
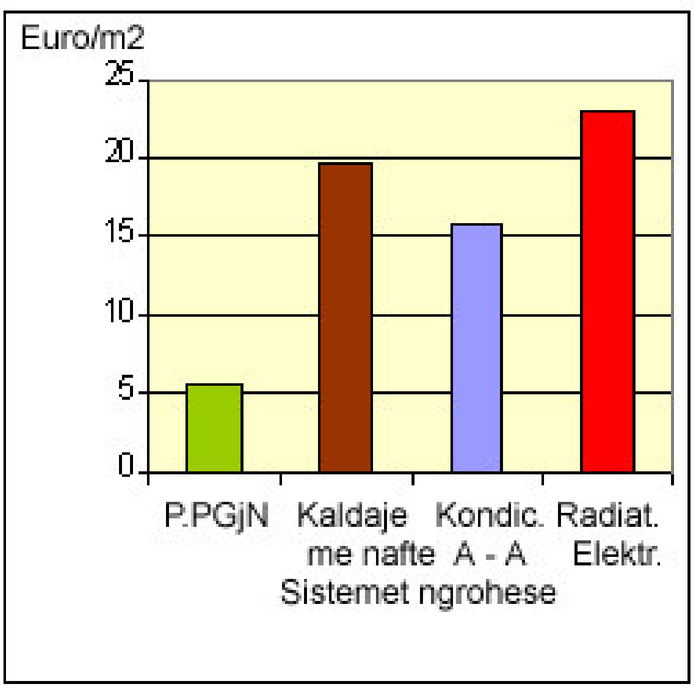


Fig. 10



. 11. Kosto specifike vjetore e ngrohjes me sisteme te ndryshme

Nga vlerësimet e bëra rezulton se kosto njësi e instalimit luhatet 70-184 Euro/m^2, si edhe 630-2120 Euro/kW, në varësi të burimeve të nxehtvsisë. Kosto më e lartë është për rastet e ndërtimit të këmbyesve vertikalë të nxehtësisë në puse. Kosto më e ulët është kur si burim nxehtësie është uji nëntokësor dhe kërkohet pus i cekët për të marrë ujin dhe për ta injektuar pasi kalon nëpër pompën gjeotermale të nxehtësisë. Siç duket nga paqyra e më sipëreme, kosto për instalimin e sistemit gjeotermal është më e lartë sesa kur ndërtohen sisteme ngrohëse me kaldajë ose edhe më kondicionerë ajër-ajër në masën 2-2.8 herë, por kjy shpenzim shlyhet për disa vjet (2-5 vjet) nga kursimi i shpenzimeve për konsumin e naftës opse të energjisë elektrike. Në figurën....... jepet grafiku i kostos në lekë për një njësi (kW) të ngrohjes. Duket qartë se sistemi gjeotermal ka koston më të vogël se të gjitha sistemet e të tjerave.

4. THIRRJE PËR INVESTIM

Zgjidhja ekonomike e problemit të ngrohjes në Shqipëri është një detyrë e ditës, tepër e rëndësishme, veçanërisht më kushtet e krizës energjetike që po kalon vendi. Një ndër rrugët e duhura është përdorimi i energjisë gjeotermale. Në Shqipëri ka një bum në ndërtimet e godinave të larta shumëkatëshe. Ato ende projektohen të ngrohen me kaldaja me naftë ose me gaz, si edhe me kondicionerë ajër-ajër. Në të gjitha godinat e institucioneve shtetërore ngrohja dhe freskimi bëhet me kondicionerë ajër-ajër, spitale, konvikte, hotele, etj ngrohen me sistemin me kaldaja me naftë ose me gaz. Ka ardhur koha, që të dilet mbi synimet e bisnesmenëve që tregëtojnë naftgë e gaz, mbi praktikat e konsumit të energjisë elektrike që paguhet nga buxheti i shtetit, ose që nuk paguhet ende. Futja e sistemeve ngrohëse dhe freskuese me anën e energjive të rinovueshme, midis të cilët atë të nxehtësisë së Tokës, duhet të fillojë të realizohet.

Për të hapur këtë drejtim të ri të përdorimit të energjisë gjeotermale, që është energji e rinovueshme dhe miqësore me mjedisin, në këtë projekt – ide propozojmë që të ndërtohet në Tiranë një instalim demonstrativ, duke ngrohur dhe freskuar një godinë. Le të jetë kjo godinë një spital ose klinikë mjekësore, një konvikt, qoftë edhe një godinë e re shumëkatëshe ose vilë private që ndërtohet.

Me realizimin e kësaj projekt ideje i bëhet apel administratës shtetërore që mbulon problemet energjetike, komunitetit të biznesit si edhe opinionit tekniko-shkencor, që të krijojnë mundësi për të bërë ngrohjen e banesave sa më ekonoimike dhe sa më mirë. Shteti, me levat e veta ekonomike duhet të stimulojë futjen edhe në Shqipëri të këtyre

sistemeve moderne dhe shume ekonomike e miqësore me mjedisin. Komuniteti i biznesit duhet ti njohë dhe të investojë për ndërtimin e sistemeve Këmbyes Nxehtësie-Pus-Pompë Gjeotermale Nxehtësie, duke hapur rrugë për biznese të reja, në plan kombëtar. Universitet teknike të shpërndajnë njohuritë për këto sisteme bashkëkohore dhe të bëhen nxitës të zbatimit të tyre në Shqipëri.

4.1. Qëllimi dhe objektivat e projektit

4.1.1. Qëllimi i projektit:

a) Projektimi dhe ndërtimi i një sistemi demonstrativ ngrohës me përdorimin e nxehtësisë së shtresave pranësipërfaqësore të tokës, ose të ujërave nëntokësore.
b) Sensibilizimi i investitorëve shqiptarë dhe i komunitetit mbi efektivitetin e lartë ekonomik për shfrytëzimin integral dhe kaskadë të energjisë gjeotermike në Shqipëri.

4.1.2. Objektivat:

1. Projektimi i një sistemi ngrohës me enërgjinë gjeotermale në një nga objektet e reja që ndërtohen ose në godina ekzistuese, që aktualisht ngrohen me system me kaldajë nafte.
2. Ndërtimi i instalimit demostrativ ngrohës i projektuar.
3. Përhapja e dijeve dhe njohurive tekniko-ekonomike për sistemet ngrohës që shfrytëzojnë nxehtësinë e Tokës., në mënyre që të bëhet atraktive për investitorët. Sensibilizimi i opinionit publik, i komunitetit te bisnesit, i administratës publike, i investitorëve shqiptarë, i pronarëve të klinikave mjekësore dhe hoteleve mbi leverdinë ekonomike të ngrohjes dhe te freskimit te godinave duke shfrytëzuar energjinë gjeotermale, në kuadrin e shfrytezimit të energjive të rinovueshme, si energji alternative.

4.1.3. Investimi i nevojshem

Për ndërtimin e sistemit demostrativ gjeotermal të ngrohjes kërkohet investim në masën që përcaktohet në varësi të madhësinë së godinës që do të ngrohet. Për këtë qëllim propozojmë që një variant mund të ishte një godinë që projektohet të ndërthet dhe të ngrohet me system ke kaldajë nafte. Mund të jetë edhe ndonjë kodinë ekzistuese, p.sh. konvikt universitar, i cili aktualisht ngrohet me kaldajë me naftë, si konvikti i Fakultetit të Ndërtimit. Fillimisht, do të ishte e përshtatshme, që ky

instalim të ndërtohet me sistemin ku si burim nxehtësije të jetë uji nëntokësor. Kjo do të bëjë që kosto të jetë më e vogël.

Mbështetur në analizën e kostos së bërë më sipër, kosto e instalimit për këto sisteme që bazohen në nxehtësinë e ujërave nëntokësore janë **70-150** Euro/m^2.

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Outlook on some result of marine geology and geophysics studies in the Albanian Adriatic Shelf

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Tirana, February 2007

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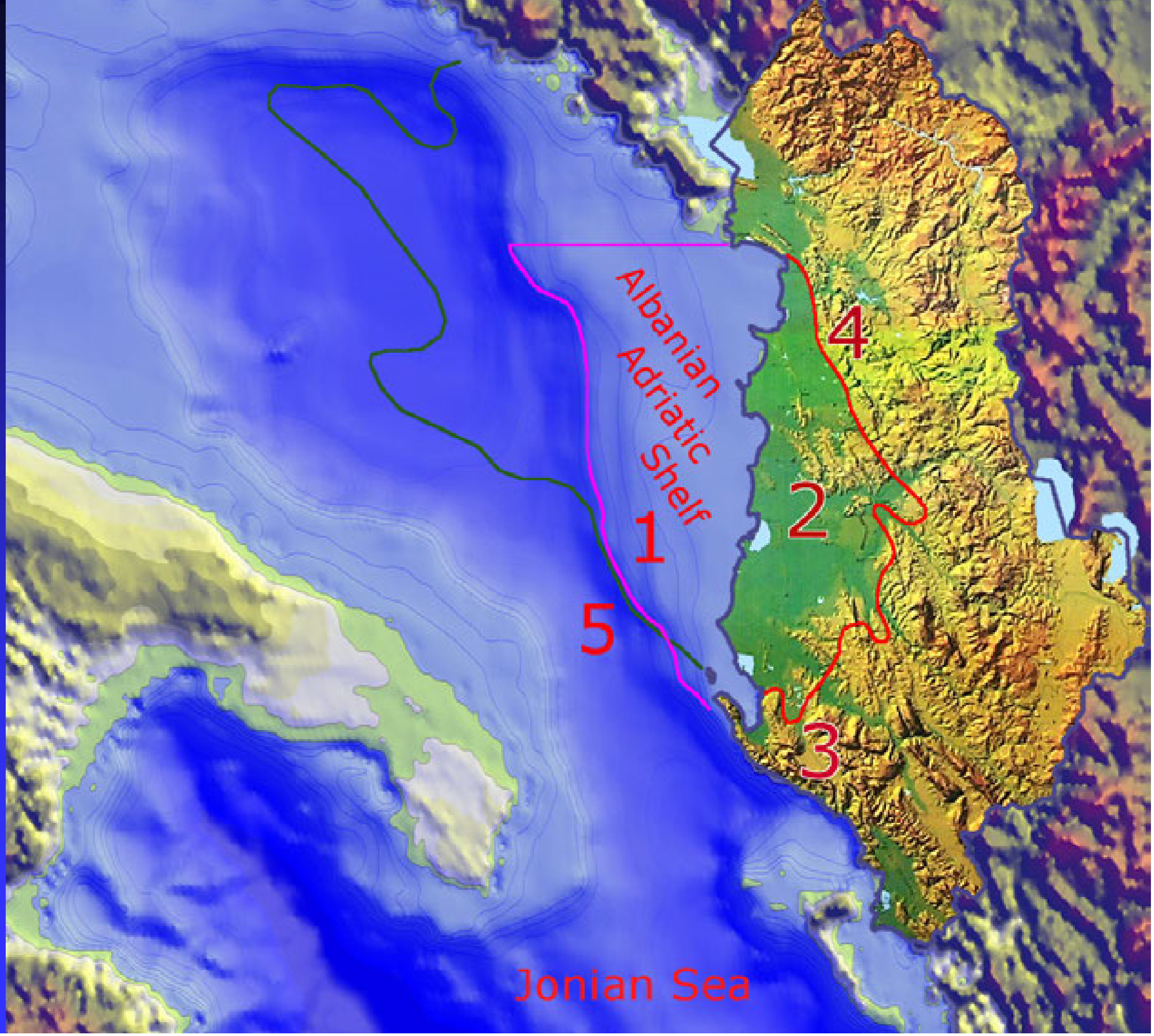
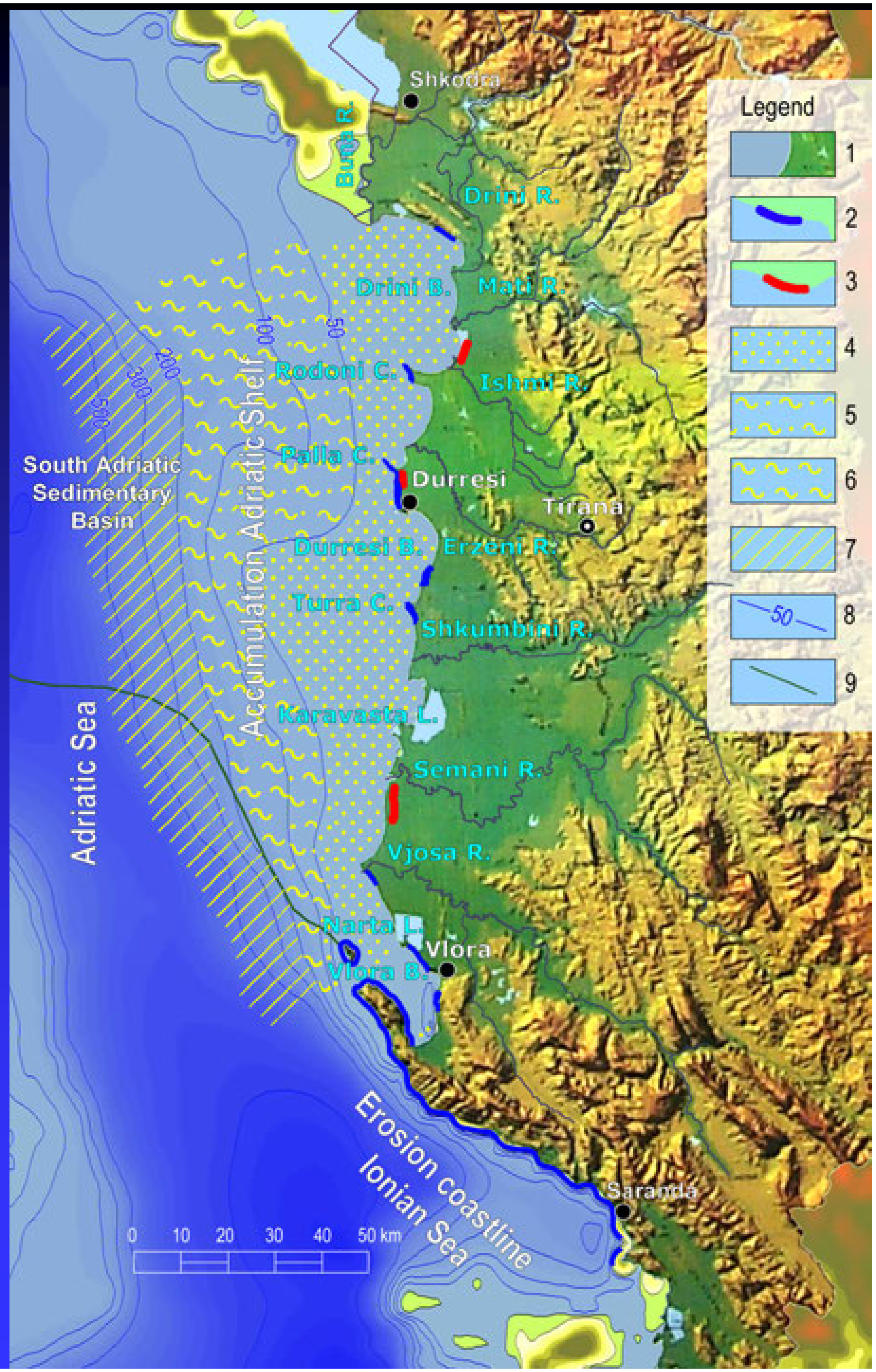
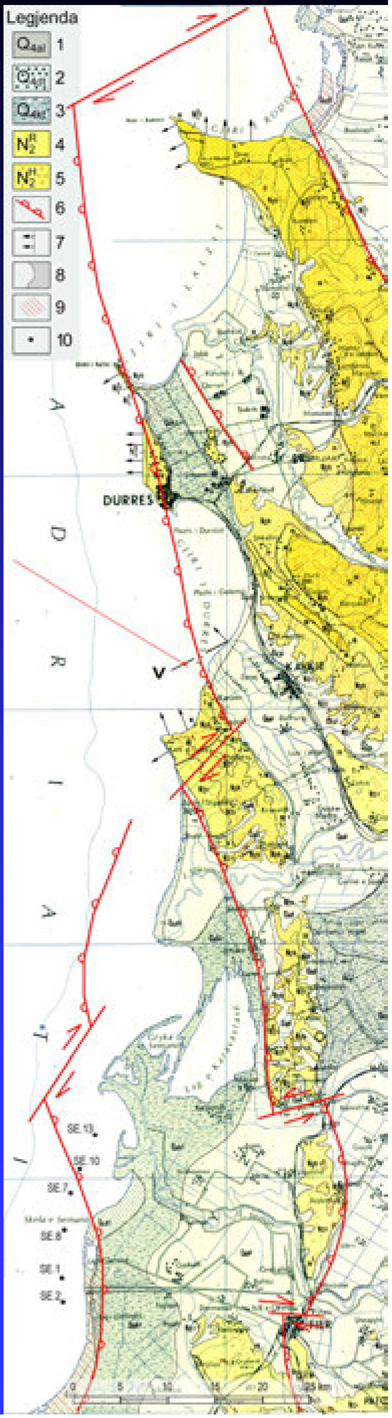
ALBANIAN ADRIATIC AND IONIAN SEAS COASTLINE AREA.



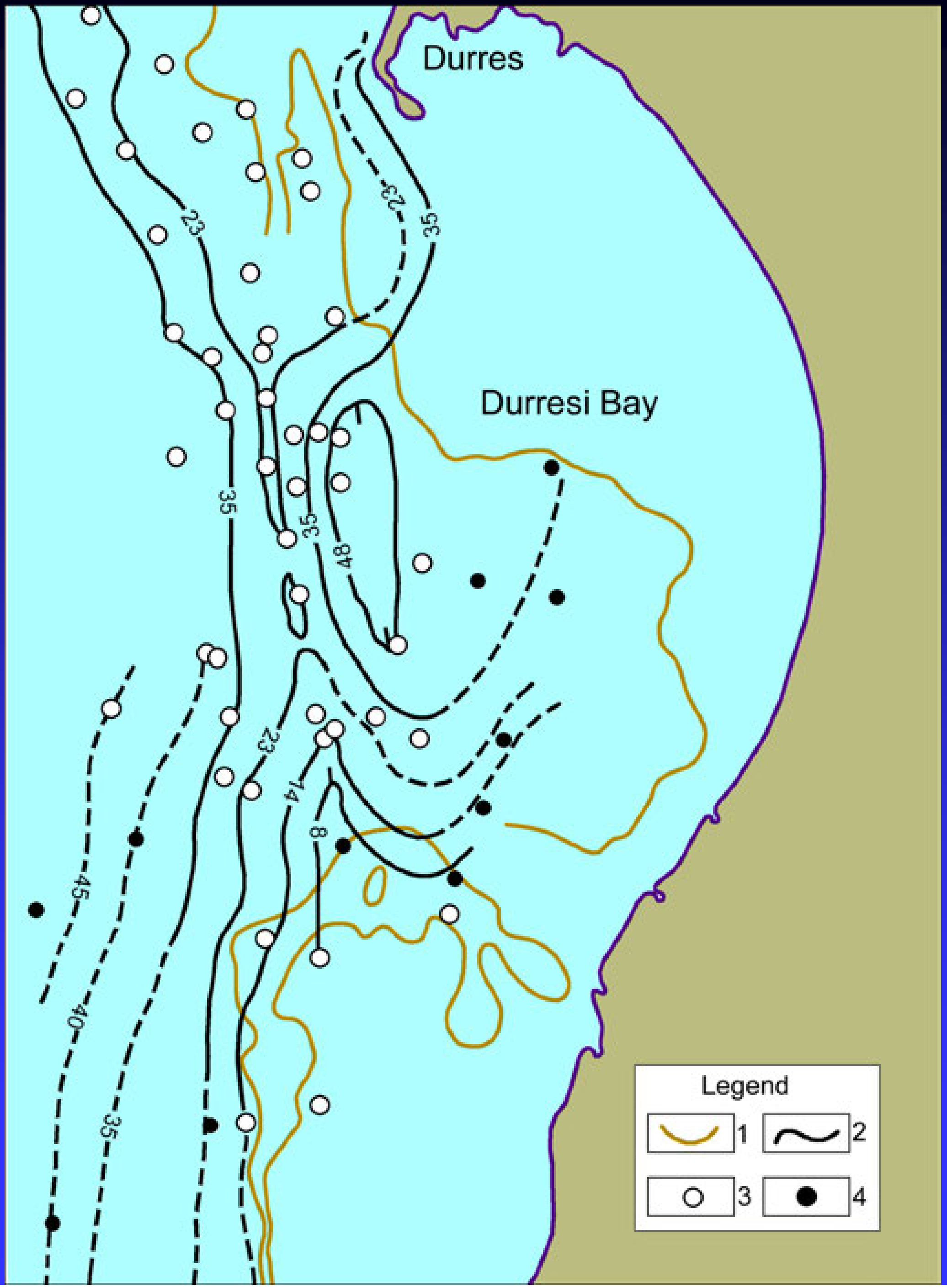
Geomorphological Scheme of Albanian Adriatic and Ionian Seas coastline.



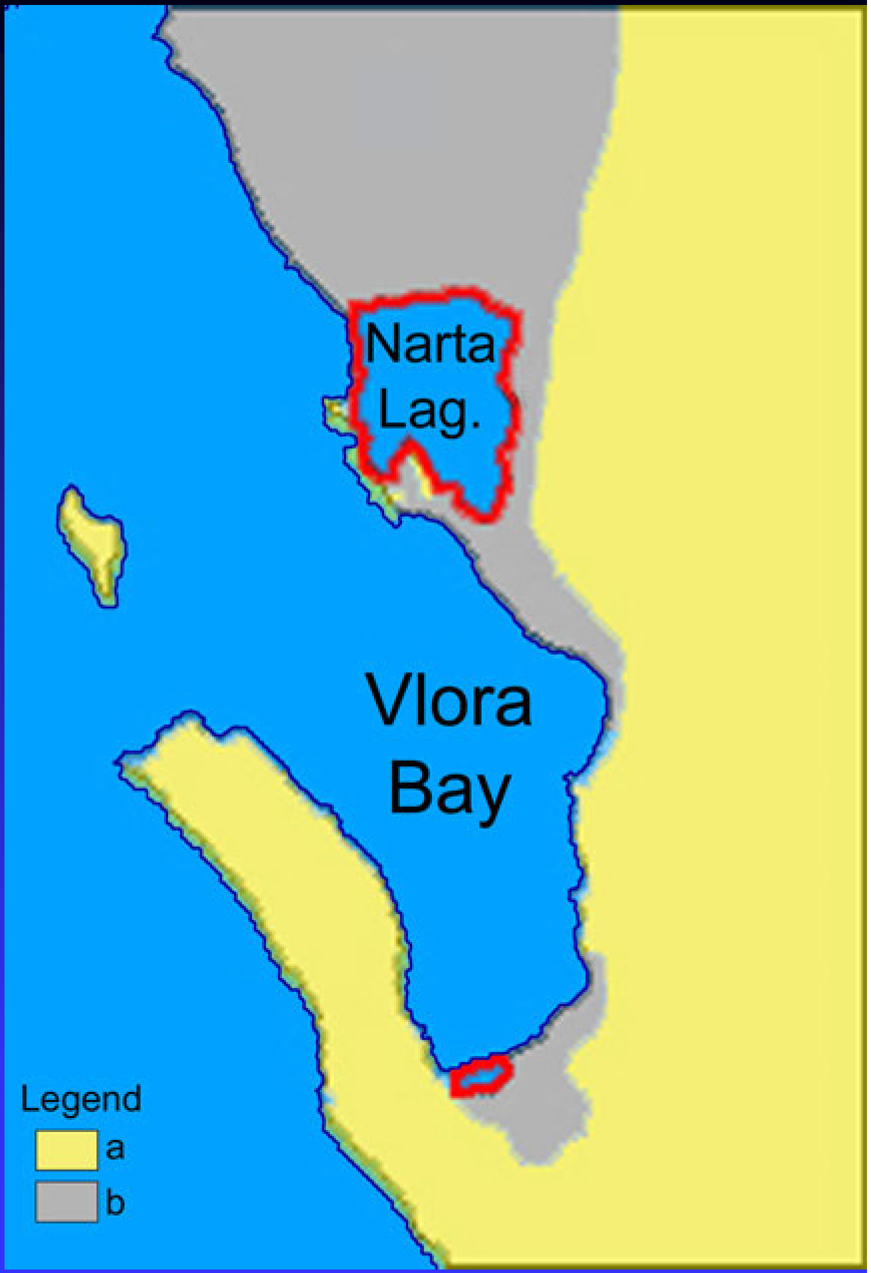
General Geomorphological Evolution view of the Vjosa River Mouth- Mati River



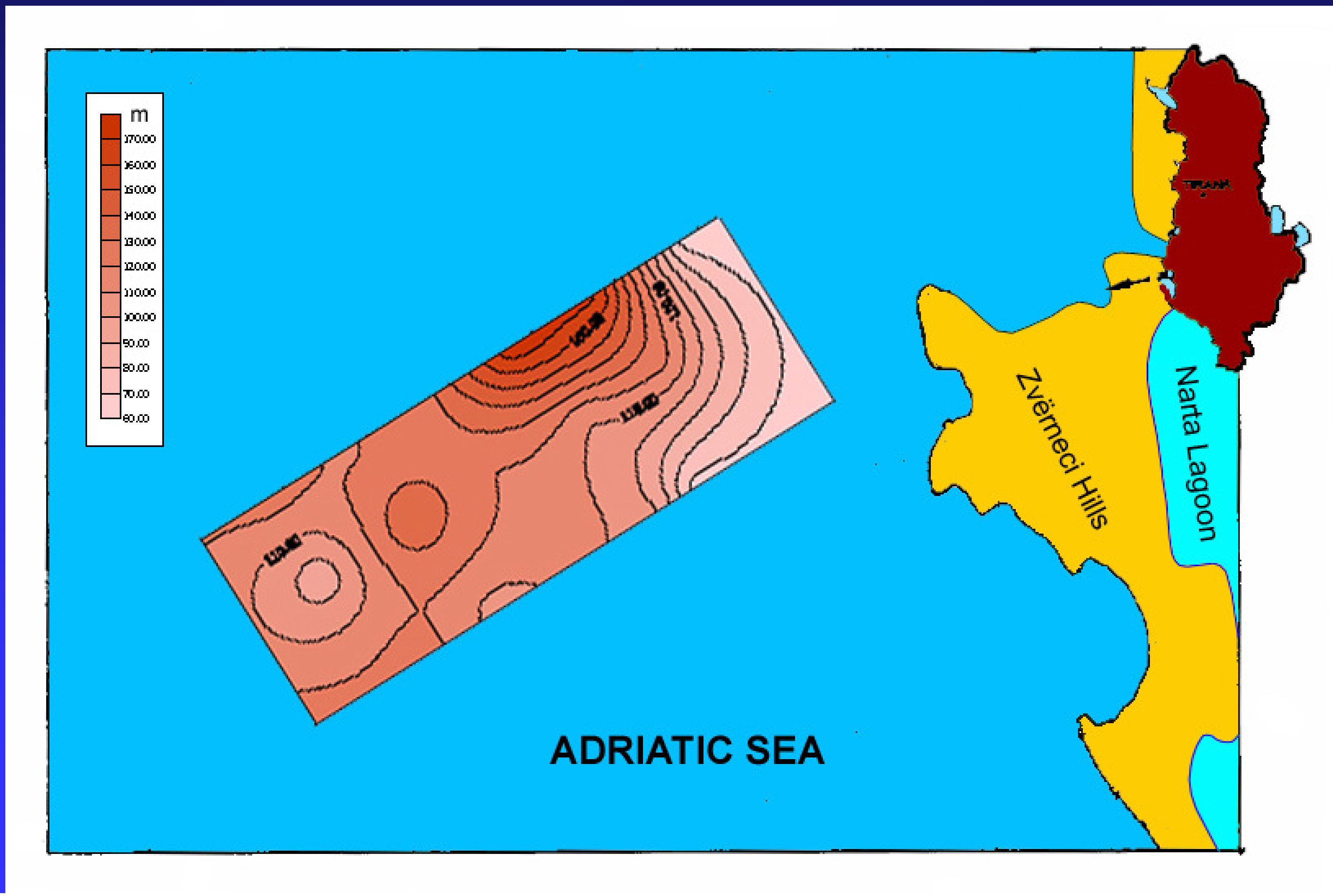
- Thickness Map of Quaternary Deposits in Durrësi Bay, according to the marine electrical soundings.



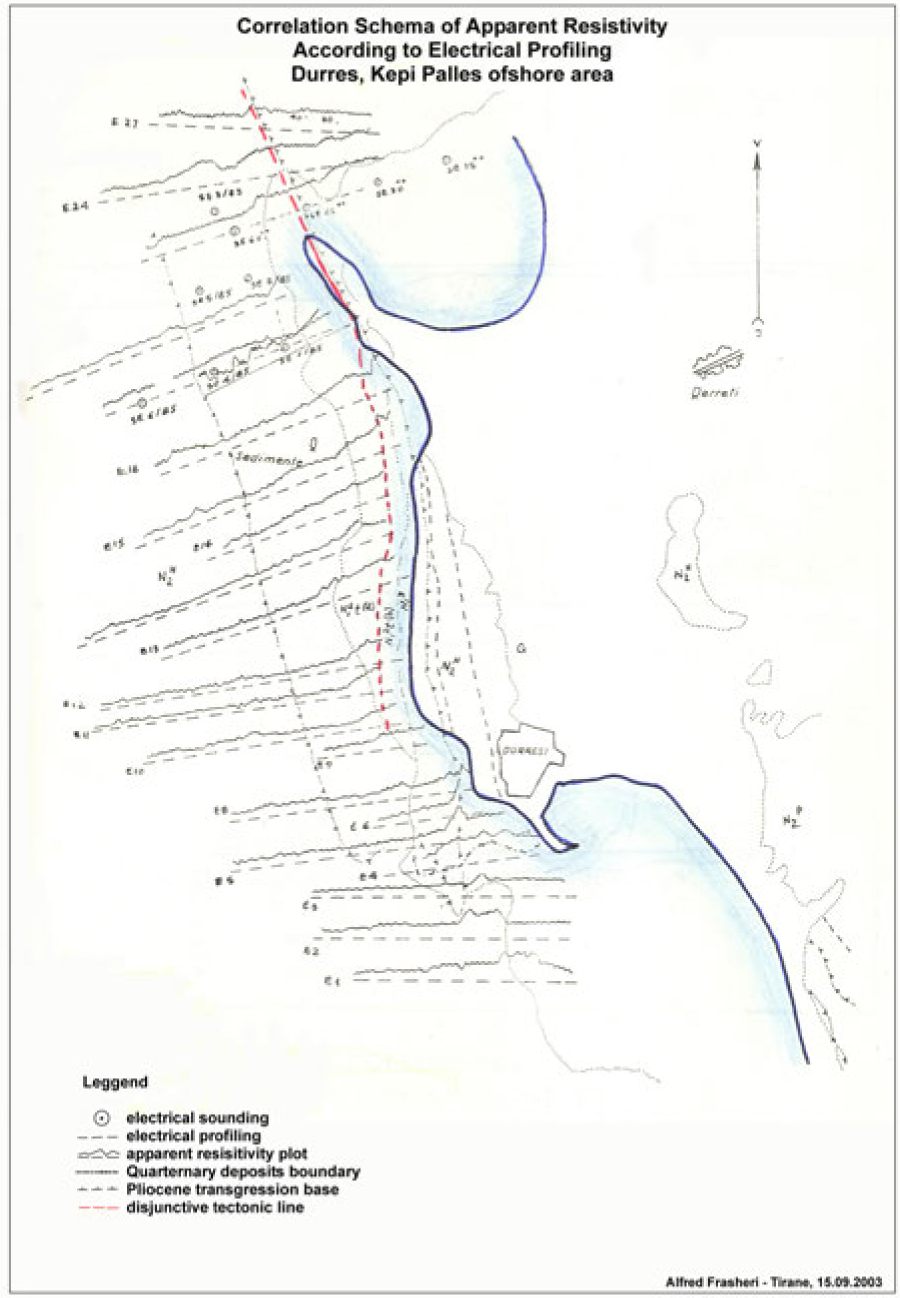
- Paleogeographic evolution of the Vlora Bay from end of Pliocene Age (a) up to Present days (b).



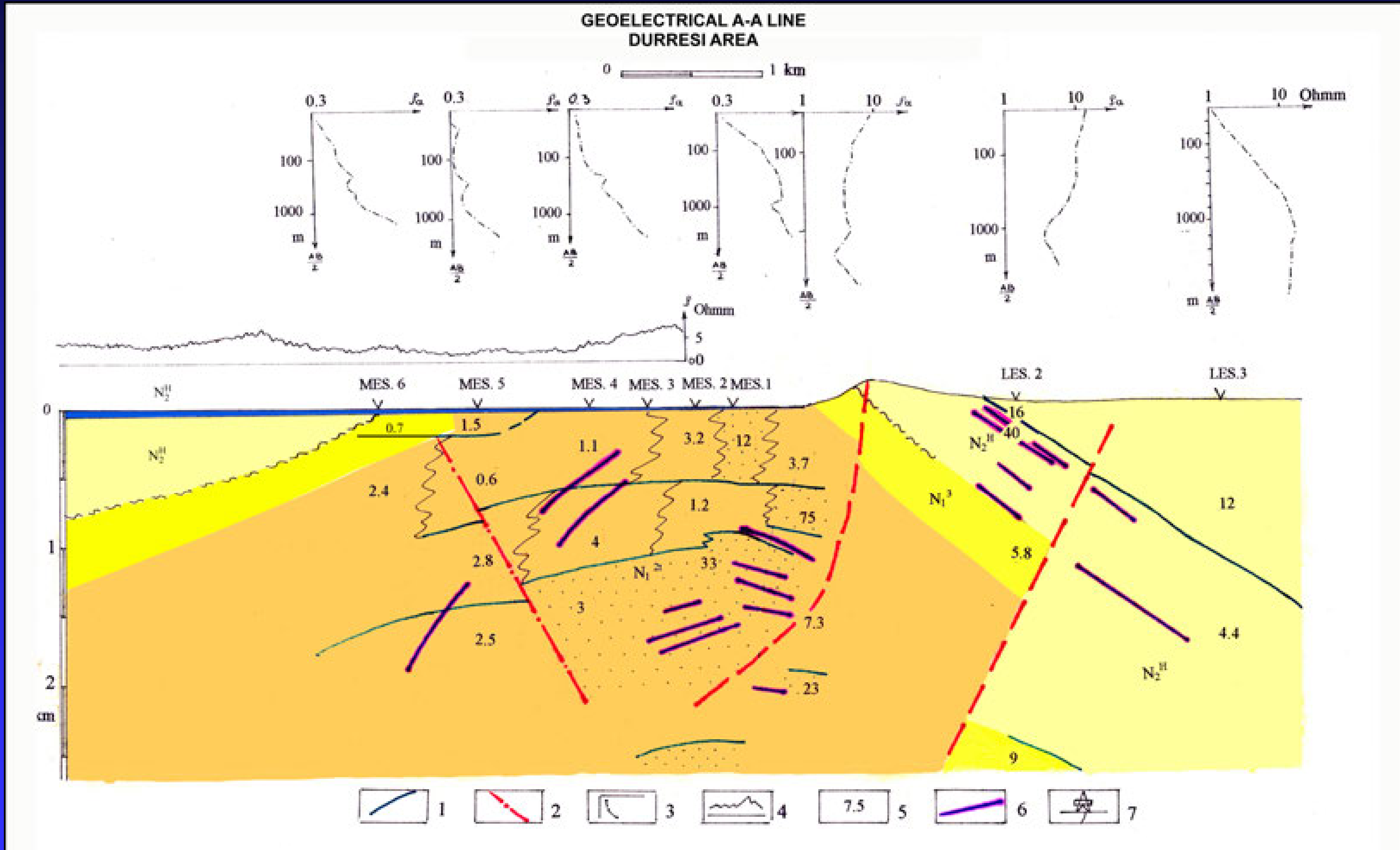
Thickness Map of Quaternary Deposits in Vlora Bay, at Zvërneci area, according to the marine electrical soundings.



- Correlative Schema of Apparetnt Resistivity according to the Marine Electrrical Profiling, offshore erosive littoral at Durrësi-Kepi Pallës area.

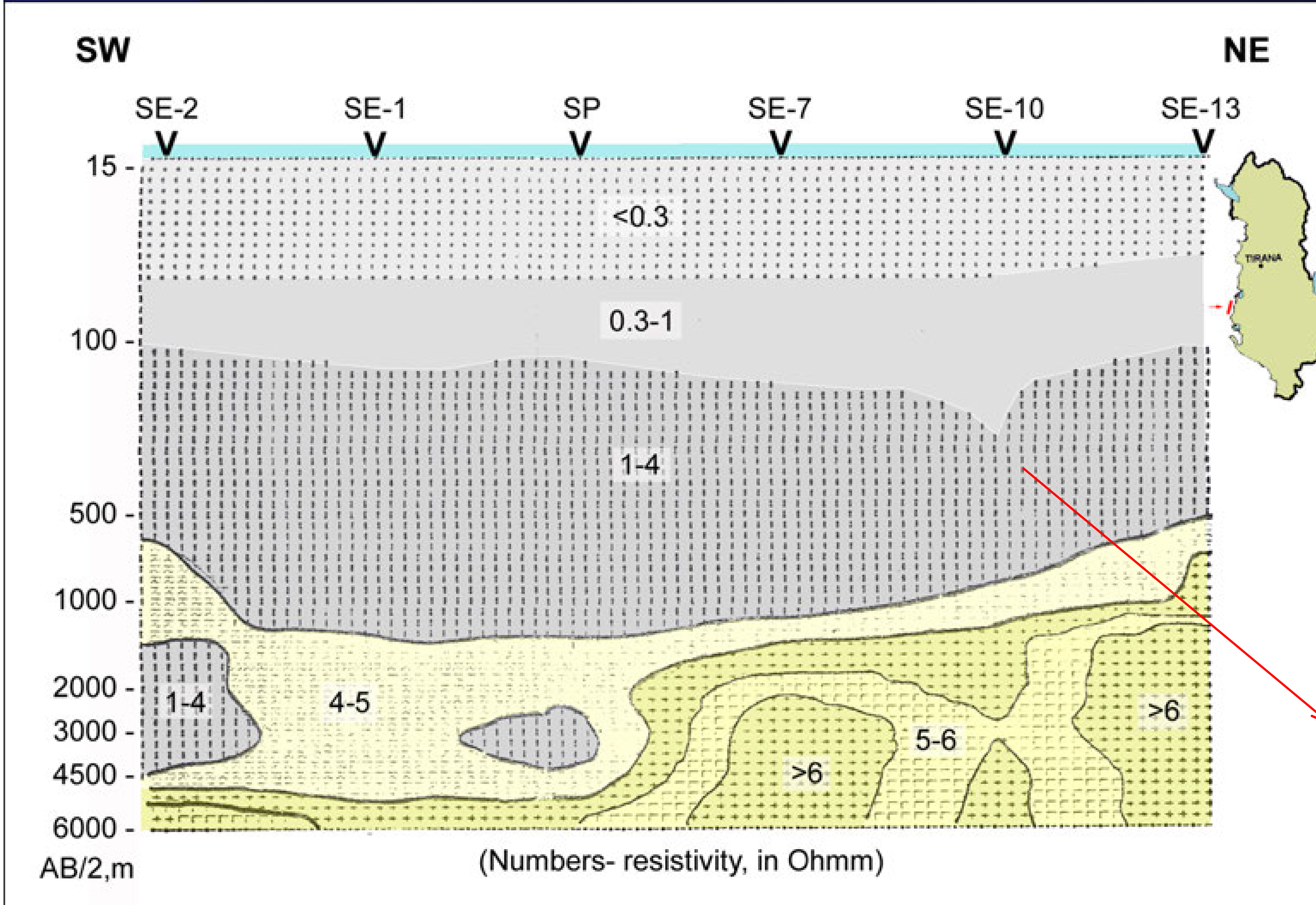


Geoelectrical Line, erosive littoral at Durrës-Kepi Pallës area.



1. Geoelectrical boundary; 2- Tectonic fault according to the geoelectrical data; 3- Electrical sounding curve; 4- Apparent resistivity profile, according to the electrical profiling with array A500M20N,C→∞ ; 5- Digits in the line show the values of the electrical resistivity of the rocks; 6- Seismic horizon; 7- deep well.

Marine Electrical Resistivity Tomography Line, Semani Adriatic Shelf.



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Geothermal features of the Albanides Folded Belt

By

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With 13 figure

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Contents

Abstract

Geothermal features of the distribution of geothermal field: temperatures at different depths and geothermal gradient, heat flow density, and geothermal resources zones, in the Albanides are presented in the paper. Based on modeling results, geothermal phenomena are analyzed up to Moho discontinuity, in two profiles across the Albanides. The temperature signals from the

Albanides depth, in the framework of the integrated interpretation with geological studies results, are analyzed.

1. Introduction

The Albanides represent an assemblage of the geological structures in the territory of Albania, and together with the Dinarides at the North and the Hellenides at the South, have formed the southern branch of the Mediterranean Alpine Belt.

Integrated regional geophysical studies have been performed during exploration accros the Albanides, onshore and in the continental shelf of Adriatic Sea. Seismological studies, gravity and magnetic surveys, reflection seismic lines, geothermal studies, radiometric investigations, vertical electric soundings and well logging were applied. Interpretations of the geophysical studies results rely on the regional geological studies data.

2. Geological setting of the Albanides

Albanides tectonic setting comprises two major peleogeographic domains: the Internal Albanides in the east and the External Albanides in the western part of Albania (Aubouen & Ndojaj, 1964, Frashëri et al., 1996, I.S.P.GJ. et al., 1983, 1985, Meço & Aliaj, 2000, Melo, 1986, Papa, 1970, 1993).

The Internal Albanides are an integrated part of the Subpelagonian Trough, and are characterized by presence of the immense and intensively tectonised ophiolitic belt, displaced from east to west forming a thrust nape.

The External Albanides represent a part of South Adriatic Sedimentary Basin, developed out of the western passive margin and continental shelf of the Adriatic plate. The External Albanides are affected only by late Miocene paleotectonic stages.

2.1. Earth crust configuration

Seismological studies, seismic, gravity, magnetic and geothermal surveys depict the Earth Crust configuration (fig. 1; 2, 3), (Aliaj, 1987, 1989, Arapi, 1982, Bushati, 1987, 1988, Frashëri et al., 1996, 2003, 2004, Koçiu, 1989, Lubonja et al., 1968, Sulstarova, 1987, Veizaj, et al. 1996).

Geophysical data reveals that the Earth crust becomes thicker from central regions of Adriatic towards Albanides mainland. The regional gravity trend in Adriatic Sea area and in the Albanides reflects the configuration of the Moho discontinuity. So, in the geological-geophysical profiles Albanid -2 (Fig. 2) is presented the decreasing of the gravity force from the Adriatic Sea region toward the Albanides because of the Moho discontinuity plunges from 25 km in the central part of the Adriatic Sea (Finetti & Morelli, 1972) to 43- 52 km at eastern part of Albanides. In the Albanides are fixed four third order trends of Bouguer anomalies of the low order: two maximums two minimums (Fig. 1). Presumably these anomalies are caused by the vacillation of the depth of roof of Moho discontinuity, and reveal a block tectonic setting of the crust, which coincides fully with seismological studies data. The sedimentary crust is 15 km thick in the Adriatic seashore and increased in northwestern regions of Albania. This tectonic setting of the deep levels of the earth crust in Albanides has its reflection even in the scattering of the magnetic fields. Considering the magnetic regional anomalies brings in conclusion that the top of crystaline basement plunges toward the littoral of the Albanides up to central areas of the Albania (Fig. 2). Consequently, the Earth crust in Albanides is interrupted by a system of longitudinal fractures of NW - SE direction and transversal fractures that, according to the seismological studies, touch into the mantel (Aliaj 1989, Frasheri et al. 1996, 2003, Sulstarova, 1987). Some of them separate even the tectonic

zones. Regional fractures have conditioned the presence of some heat flow anomalies and geothermal zones, where thermal springs are located.

2.2. Tectonic zones

Based on geological and geophysical regional studies and regarding the facial-structural criterion, across the Albanides are distinguished the following tectonic zones (Fig. 5):

A) Internal Albanides: *Korabi, Mirdita, Gashi tectonic zones,*

B) External Albanides: *Albanian Alps, Krasta-Cukali, Kruja, Ionian, Sazani tectonic zones, and Peri Adriatic Depression.*

Internal Albanides. The tectonic zones of the Internal Albanides lie along the eastern part of Albania.

Korabi zone (K), (analogue of the Pelagonian zone in Hellenides and Golia zone in Dinarides). In this zone outcrop the oldest formations of Paleozoic in Albania. Gravity Bouguer anomaly configuration in the Korabi zone reveals that Korabi zone structures are of low orders (Fig. 1). The contact between Korabi and Mirdita zone coincides with a deep seismogene structure (Sulstarova, 1987).

Mirdita zone (M), (analogue of the Subpelagonian zone in Hellenides and Serbian zone in Dinarides). Three tectonic stages are formed in this zone during the different orogenic phases. The lower nappe is made up of ophiolites. The ophiolitic belt is characterized by intensive Bouguer anomalies and by a magnetic field with weak and turbulent anomalies (Figs. 1, 2) (Bushati, 1997, 1998, Frashëri et al., 1996, 2003). There are three characteristics of the anomalous belt in Mirdita zone:

- The anomalies are divided in two parts, at the north and at the south of Shengjergji flysch's corridor.

- There are five gravity maximums, with epicenters set one after the other in an anomalous chain from the northeast part of Albania to its southeastern area. The anomalies have maximal amplitude up to 105 mGal and strong gradients that separate them from each other. The anomalous belt undergoes an obvious turn of 60^o-70^o toward the direction of the Dinarides ophiolitic belt in the northeastern part of Albania.
- The biggest amplitudes of the anomalies came from the northern part of ultrabasic massifs of the eastern belt.

The biggest thickness of ophiolitic belt is about 14 km at its northeastern edge, but it decreases up to 2 km towards the west and southeast. This geological setting demonstrates the allochtonous character of ophiolites belt and the covering character of their western contact onto the formation of the Krasta-Cukal zone of External Albanides. The tectonic relationships between the Internal and the External Albanides have nappe character (Cadet et al., 1980, Frashëri et al., 1996, 2003, Hoxha, 2000, Hoxha & Avxhiu, 2000, Lubonja et al,. 1968, Melo, 1986, Papa, 1993, Qirinxhi, 1970). There is presented also the autochthonous character of the Albanides ophiolitic belt (I.S.P.GJ. et al., 1983, 1985, Becaluva et al,. 1994, Gjata & Kodra, 2000, Kodra, 1998, Shallo et al., 1989, Robertson et al., 2000).

The molasses post-orogenic deposits have covered transgressively Mirdita and partially Krasta–Cukali tectonic zones in Korça and Burreli internal depressions developed during the tarditectonic-neotectonic stages.

Gashi zone (G). (analogue of the Durmitory zone of the Dinarides) at the north of Albania. It consists of metamorphic rocks, terrigeneous rocks, limestone, metamorphic volcanites, as well basic intermediate and acidic rocks.

External Albanides. The tectonic zones of the External Albanides outcrop chiefly in the western part of Albania (Aliaj, 1987, 1989, Bare et al., 1986, Dalipi, 1985, Frashëri et al., 1996, 2003, Mëhillka et al., 1999, Xhufi & Canaj ,1999, Prenjasi, 1992, Prenjasi et al., 2003).

Albanian Alps zone (A), (analogue of the Parnas zone in Hellenides and High Karst in Dinarides) at the north of Albania. Sandstone and the conglomerates of Permian are the oldest rocks, which outcrop in this zone. In general, the Albanian Alps represent limestone monoclines, as well as smaller anticlines in their background. A regional gravity minimum extends on the Alps zone (Fig. 1).

Krasta-Cukali zone (KC), (analogue of the Pindos zone in Helenides and in Budva zone of the Dinarides). It is an intermediate zone between the Internal and External Albanides, and is divided into two subzones of Cukali and Krasta:

The Cukali subzone extends in the north of the Krasta-Cukali zone. It is composed of Triassic-Cretaous carbonate rocks, some middle Triassic effusive rocks and few radiolarites at the top of Upper Jurassic, overthrusted onto the Maastrichtian-Paleocene-Eocene flysch. The Cukali subzone represents a big anticline in its background. The Alps and Mirdita zones overthrust onto this subzone.

Krasta subzone extends from Shkodra city in the North to Leskoviku in the southeast. Three formations outcrop in this subzone: the Albian-Cenomanian early flysch, Senonian limestone serie and Maastrichtian – Eocene young flysch. The latter flysch appears obviously as a tectonic window even in Shen-Gjergji corridor, between two ophiolitic belt parts.

Kruja zone (Kr), (analogue of the Dalmateian zone in Dinarides and the Gavroro one in Hellenides). The Kruja zone consists of a series of anticline structures with Cretaceous-Eocene carbonate cores of neritic limestones; dolomitic limestones and dolomites covered with the Oligocene flysch deposits. Tortonian molasses overlies transgressively the carbonate

rocks of some structures of the Kruja zone, while in some other ones; the Burdigalian premolasses transgress on the flysch section.

The carbonate section of the Kruja zone is plonged down up to 10 km, where they are underlain by the Triassic evaporite formations. Anticline structures of this zone are asymmetric and some of them have their western flanks desected by disjunctive tectonics. Most of them are of linear type reaching maximum length of 52 km.

Ionian zone (Io) extends in the southwestern part of Albania, which continues in the Hellenides, too. It is the widest zone of the External Albanides, developed as a deep pelagic trough since the Late Liassic. The upper Triassic evaporites are the oldest rocks, which outcrop in this zone. Over this formation lies a thick sequence composed of upper Triassic-lower Jurassic dolomite limestone and Jurassic-Cretaceous-Eocene pelagic limestone and cherts. The limestone section passes on gradually into the Oligocene flysch, Aquitanian flyschoidal formation, and Burdigalian-Langhian and partially of Serravalian-Tortonian premolasses. Significantly flysch deposits overlie carbonate oil field and prospects, whereas the Burdigalian and Tortonian molasses often lay on them. This phenomenon has brought about a geological setting of two tectonic stages (Fig. 3).

Integrated geological-geophysical data show the presence of many anticline carbonate structures often seatled with flysch deposits along the three facial-structural belts of the Ionian zone.

Two main tectonic styles are apear in the Ionian zone: Duplex tectonics and imbricate one. The anticline structures are desected by longitudinal tectonic fault along their western flanks. Recumbent, and overthrusted-eroded structures thrusted up to of 5-6 km horizontal displacement are also present (Prenjasi, 1992). The overthrustig phenomenon has been stimulated periodically by tectonic rejuvenation of the regional faults. The backthrust faults

have happened owing to retrotectonic phenomenon (Aliaj, 1987, 1989, Fezga et al., 1996, Valbona et al., 1987).

The regional reflection seismic lines across the Ionian zone show that the undethrusting limestones of the southern Adriatic basin and Sazani Zone have taken place during the structuring process of the Ionian zone (Fig. 3).

Sazani zone it is an integrated part of the Apulian platform, buldet of a thick Cretaceous-Eocene limestone and dolomite section, widely overlied by transgressive sequences of Burdigalian to Tortonian premolasses.

Peri-Adriatic Depression. This unit covers transgresively considerable part of the Ionian, Sazani and Kruja tectonic zones. This is a foredeep depression filled with Miocene to Pliocene-Quaternary molasses (Fig. 3). The thickness of the molasses increases from southeast to northwest, reaching 5000 m. Ussually; the molasses deposits lay trangressively on the older ones, down to the limestone and erect a two-stage tectonic setting (Fig. 3).

The External Albanides, as a part of Albanian Sedimentary Basin, continue towards the shelf of the Adriatic Sea with carbonate and terrigene formations. The stratigrafic column of Albanian Sedimentary Basin is about 15 km thick.

3. Geothermal study method

The studies on the geothermal field and evaluation of the geothermal energy in Albania, in the cource of the preparation of "Atlas of Geothermal Resources in Albania", European Geothermal Atlas and European Geothermal Energy Resources Atlas, have performed on the basis of the temperature logs of 84 oil and gas wells and 59 shallow boreholes. The temperature was measured with either resistance or thermistor thermometers. Thermal inertia of these thermometers is respectively 5-6 seconds and 3.5 seconds. The thermal conductivity

of the rocks was determined in the Laboratory of Department of Geothermics of the Geophysical Institute, Czech Academy of Sciences, Prague. Heat-flow density calculations are made for homogenous lithology of geological sections, according to several models. The temperature maps at 100, 500, 1000, 2000, 3000 meters depths below surface, average geothermal gradient map, heat flow density map and geothermal zones map, are made up by the processed data. The maps of the Albanian territory are linked with Greek and Adriatic ones.

Geothermal models rely on several regional geological-geophysical profiles. Temperature distributions up to 50 km depth, according to the modeling data are presented in two profiles: Albanid–1 (Falco Italy-Semani coastline Albania-Bilisht near of Albanian-Greek Border at SE part of Albania) and Albanid-2 (Falco Italy-Durrës-Tiranë-Peshopi NE part of Albania) (Frashëri et al., 2004). Results of these modelings are used to interpretat the Heat Flow Density Map of Albania.

Also have been performed gothermal investigatigation of the thermal water springs and deep wells, and evaluated the geothermal resources of the thermal zones. The estimation of geothermal potential of the reservoirs is based on a volumetric heat content of the model.

4. Geothermal regime of the Albanides

The geothermal regime of the Albanides is conditioned by tectonics of the region, lithology of geological section, local thermal properties of the rocks, and Earth’s crust settings (Frashëri et al. 2004).

4.1. Temperature

The geothermal field is characterized by a relatively low temperature gradient. The temperature at the depth of 500 meters depth is between 21 and 24°C. The highest temperatures, up to 36 °C at 1000 meters and 105.8 °C at 6000 meters depths are measured in Peri-Adriatic Depression wells. The same values of temperatures also are measured in some boreholes in the ophiolitic belt. The lowest temperature values have been measured in mountain regions of Mirdita zone, as well as in the Albanian Alps. In these areas are present an intensive circulation of cold descendings waters, of 5-6 °C temperature. The arrangement of isotherms fits well to the structures of Albanides.

The described geothermal field, with relatively low values of temperature, is a characteristic of the sedimentary basins with great thickness of sediments.

4.2. Geothermal gradient

External Albanides as well as the Dinarides are characterized by a low geothermal gradient, (Fig. 4).

Structural and facial lithological variations of the Ionian zone and the Peri-Adriatic Depression are reflected in the distribution of geothermal field. The tectonic setting of the region, geological section lithology, and rocks thermal properties has conditioned the geothermal gradient value. The largest gradients are detected in the molassic anticline structures of the center of Peri-Adriatic Depression (Fig. 4). The highest values of the geothermal gradient of about 21.3 $mK.m^{-1}$ are observed in Pliocene clay section (Fig. 5). The gradient decreases about 10-29 % is observed at carbonate anticline structures of the Ionian zone (fig.6), whereas elsewhere along this zone the gradient is mostly 15 $mK.m^{-1}$. Extremaly low geothermal gradients values of 5 $mK.m^{-1}$ are observed in the Southern part of Albanides and in the Albanian Alps. Furthermore the gradient in these cases (Fig. 7) decreases towards

the zero or becomes negative, especially wherever the cold surface waters flow into the anticline's limestones. Meanwhile the lowest values (7-11 $mK.m^{-1}$) of the gradient are observed in the deep synclinal belts of Ionian and Kruja zones.

Modeling results indicate that the gradient decrease deeper takes place at depth than 20 km, which coincids with the crystaline basement top.

In the Albanian Sedimentary Basin, geothermal gradient is stricts controlled by the lithology. Its highest values of geothermal gradient vere observed in the clay sections. Whereas increasing of sand content in geological section is associated with the geothermal gradient decrease. In the conglomerate-sandstone part of the Rrogozhina suite of Pliocene, the geothermal gradient is almost two times lower than in the Helmesi clay ones.

The influence of salt diapir is also obvious; the high thermal conductivity of salt perturbes the isotherms.

Over-pressures presence in the molasses section of the Albanian Sedimentary Basin has is dedected by a increasing of the geothermal gradient.

Deviations from the normal trend of the above-mentioned phenomenon occur in cases of lateral influences. For example in the fig.8 shown that gradient reaches its smaller values in the lower part of the section, owning to the presence of a limestone structure beside the east of the Ardenica 18 well.

Along the ophiolitic belt of the Mirdita zone, the geothermal gradient values increase up to 36 $mK.m^{-1}$ at northeastern and southeastern part of the Albania (Fig.3). In this belt is also observed the existence of a lower gradient section, up to 10 $mK.m^{-1}$. This gradient decrease is explained by the convection influence related to the infiltration of cold meteoric water.

After the geothermal modeling, decreasing of the gradient is observed even deeper than 12 000 meters under the ophiolites of Albania, at the top of the Triassic evaporate deposits.

4.3. Heat Flow Density:

The regional pattern of heat flow density in Albania is presented in fig. 9, where are depicted three particularities of the scattering of the thermal field in Albanides:

Firstly, the maximum value of the heat flow 42 mW/m^2 in the center of Peri-Adriatic Depression of External Albanides is observed. The 30 mW/m^2 isotherm is open towards the Adriatic Sea Shelf. Heat flow density values are lower than 25-30 mWm^{-2} in Albanian Alps area due to the presence of a greater thickness of sedimentary contenental crust, mainly carbonatic one in this zone.

In the ophiolitic belt of the eastern part of Albania, the heat flow density values are up to 60 mW/m^2. The contours of heat flow density give a clear configuration of the ophiolitic belt. The contours of 45 mW/m^2 in Northeast and 40 mW/m^2 in Southeast of Albania remain open toward the ophiolitic belt continuation beyond the Albanian border. While very low values of radiogene heat generation of the ophiolites means that increasing of the heat flow in this ophiolitic demonstrate heat flow transmitting from the depth. On the other hand the highes values of the ophiolitic belt heat flow density must belong to the small thickness part of the geological section down to the top of crystalline basement, and MOHO discontinuity (Fig. 2). Certainly the granites of the crystalline basement, with the radiogenic heat generation, represent the main heat source.

In the ophiolitic belt there are observed some local hearths of higher heat flow density. Heat flow anomalies are conditioned by intensive heat transmition along deep and transversal fractures (Fig. 9).

4.4. Paleotemperature estimations

Paleotemperature modeling results indicate that maximum temperatures of up to 105.3 ^{o}C were obtained during Upper Triassic-Lower Oligocene age in the Albanian Sedimentary Basin. In these paleotemperature conditions has taken place the thermal maturation of the organic matter of carbonate formation, which has entered into oil window. Upper Triassic up to the Lower Oligocene age formations of the Albanian sedimentary Basin represent the section of the first phase of the hydrocarbon generation of condensate, oil and gas. Later, during the Middle-Upper Oligocene and Miocene, the carbonate section was plunged at greater depth, where the temperature ranges maximum to 250 ^{o}C. This geothermal regime has created the thermal conditions for the phase of the methane generation.

Maximal temperatures up to 122.8^{o}C, with a geothermal gradient 1.67 mK/m and heat flow density ranges 39.8-41.2 mW/m^2 during the Middle and Upper Miocene have created the thermal conditions for maturing the organic matter of the molasses formation. Good thermal conditions for maturing of the organic matter exist also in the Pliocene section. Actually, by the general interpretation the oil of molasses section is correlated with the source rocks of the carbonate section. The molasses oil traps generally are located transgresively over the eroded top of the limestone anticlines. The hydrocarbon migration has taken place through this eroded surface. Thermal regime of the Middle-Upper Miocene, with the temperatures up to 122.8^{o}C and heat flow density 41.2 mW/m^2, creates the possibilities of molasses to entire into oil window and organic matter to be able also for the oil generation.

4.5. Geothermal Zones

Large numbers of geothermal energy of low enthalpy resources are located in Albania. Thermal waters of a temperature that reach values of up to 65.5 °C are sulphate, sulphide, methane, and iodinate-bromide types. The geothermal energy comes through seismoactive

deep longitudinal NW-SE and transversal fractures of the Earth crust in the Albanides that have desected the mantel (Fig. 11). According to the calculation of different geo-thermometers, the geothermal aquifer estimated temperatures ranges from 144 to 270^{o}C, while, the geothermal modeling, suggests that thermal waters rises from 8-12 km depth section, where temperature attains to 220^{o}C.

Thermal sources are located in three geothermal zones (Fig. 10):

Kruja *geothermal zone* is the area of the biggest geothermal resources in Albania, with a length of 180 kilometers and a width of 4-5 kilometers. It starts on the Adriatic coast northwest of Tirana and continues southeast to Albanian-Greek border. The Kruja geothermal area represents an anticline structure chain. Geothermal energy resources are controlled by western regional thrust tectonics of the Kruja tectonic zone. Geothermal aquifer is represented by a karstified carbonate formation with numerous fissures and microfissures. In a regional view, limestones plunge down to 10 km, where they overlie Permian-Triassic evaporitic formation. In these depths, the temperature ranges between 120-150°C. Surface springs water temperatures in the Tirana-Elbasani northern subzone vary from 60°C to 65.5°C, and yields for long periods of time, some 3.5 to 15 l/sec. Hot water is stronglu mineralized, salt concentration range from 4.6 to 19.3 g/l.

In the southern subzone, thermal water flows out from the contact between the Eocene fissured and karstified limestones and the flysch section. Waters temperature is 27.6-29 ^{o}C and yield 70-80 l/sec. These waters are poor in H_2S and CO_2 and 7-9 times less mineralized than waters from the Tirana-Elbasani subzone.

The most important geothermal resources are located in the northern half of Kruja Geothermal Area. The heat in place (H_o) is 5.87 x 10^{18} – 50.8 x 10^{18} J, identified resources (H_i) are 0.59 x 10^{18} – 5.08 x 10^{18} J, while the specific reserves ranges between values of 38.5-

39.6 GJ/m^2. The southern subzone has lower concentration of resources 20.63 GJ/m^2, while geothermal resources amount to 0.65 x 10^{18} J.

Ardenica *geothermal zone* is located in the coastal area of Albania. It comprises several molassic-Neogenic brachyanticlines and deep carbonatic structure. At the surface, the boreholes discharge waters at temperatures of 32-67 ^oC. Thermal water is Ca-Cl type. The Ardenica reservoir heat in place is of 0.82 x 10^{18} J. Resources density varies from 0.25-0.39 GJ/m^2.

Peshkopia *geothermal zone* is located in the Northeast of Albania where waters of 43.5 ^oC flow out of a group of thermal springs. Some of the springs yield flow rates up to 14 l/s. The occurrence of these springs is condicioned by a deep fault at the periphery of a gypsum diapir of Triassic age that has penetrated the Eocene flysch. The thermal waters are of sulphate-calcium type, with a mineralization of up to 4.4 g/l, and 50 mg/l H_2S. Geothermal resources of Peshkopia Area have been estimated similar to those of Tirana- Elbasani area.

5. Geothermal phenomenon and Adriatic Sea hydrography

Epicenter of the heat flow density anomaly at the Adriatic Sea bottom (Fig. 12) (Geothermal Atlas of Europe 1992) is located at southwestern prolongation of the Scutary-Pec regional transversal tectonic accros the Albanides onshore onto Adriatic offshore. According to the paleomagnetic study results, the Scutary-Pec lineament forms the transition between two zones: the Albanian Alps and Dinarides with counterclockwise rotation to its north and the Albanides and Hellenides with clockwise rotation to its south (Mauritsch, 2000). Offshore prolongation of Scutary-Pec transversal correspond also with the "The Bridge" of continental water with high temperatures, low salt content and density of the seawaters in the Adriatic Sea

observed by Albanian Oceanographic Expeditions during the wet years (Pano, 1994) (Fig. 13).

6. Conclusions

1. Heat flow density distribution arguments block character of the crystalline basement in the Albanides. Depth location of these blocks is smaller in the Mirdita zone of the Inner Albanides than in the External Albanides.

2. Albanian Sedimentary Basin by relatively low temperatures at depth is characterized. The temperature reaches only 105.8 °C at the depth of 6000 m.

3. The geothermal gradient value in the External Albanides ranges between 7 - 11 mK/m and 21.3 mK/m. This gradient increases to 36 mK/m, in the ophiolitic belt of Inner Albanides.

4. The heat flow density is about 42 mW/m^2 in the center of the Pre-Adriatic Depression and up to 60 mW/m^2, east of the ophiolitic belt.

5. Tectonics setting of the region and lithology of geological section condition their geothermal gradient value.

6. Local anomalies of the great heat flow density in some ophiolitic areas are interpreted as presence of the deep transversal fractures.

7. The geothermal reservoirs are located along the seismically active belt.

8. Afret paleotemperature investigations, depth of the Albanian Sedimentary Basin has perspective for the methane reservoir discovery.

9. Interpretation of the paleogeothermal regime of the Albanian Sedimentary Basin offers new possibilities to discover oil pools in the Miocene molasses suitable traps, which don’t contact directly with the eroded limestone sections.

10. Direct use of the low enthalpy geothermal energy resources in Albania, as an alternative of the environmental friendly energy, is based on important geothermal reserves in the Albanides.

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LIST OF CAPTIONS

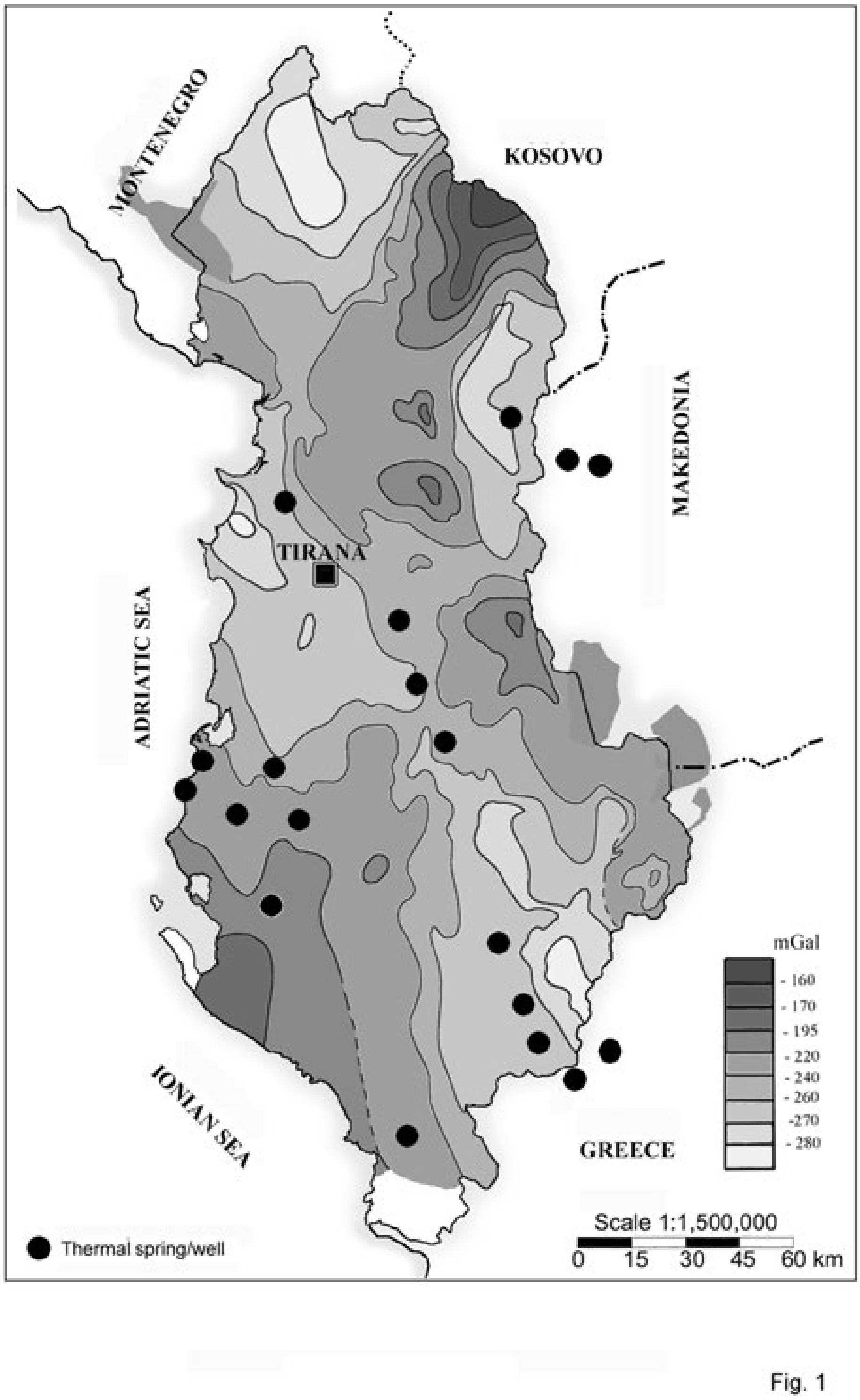
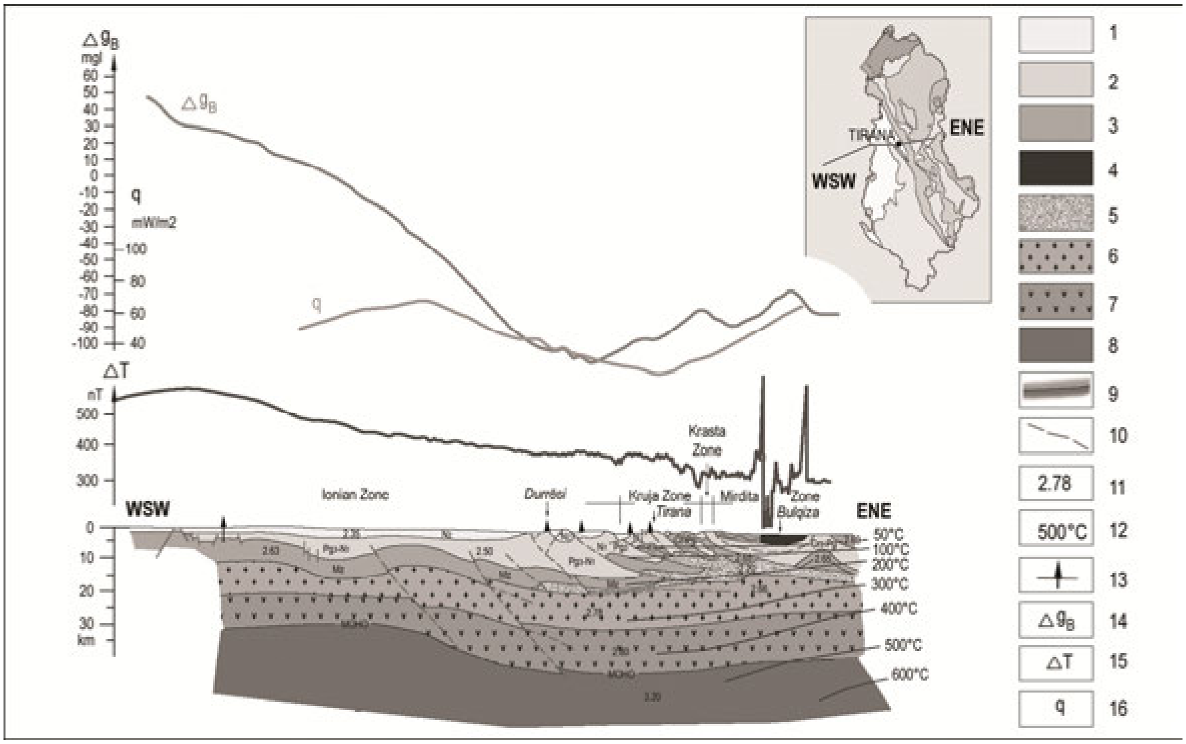


Fig. 1. Bouguer gravity map of Albania (Bushati, 1988).



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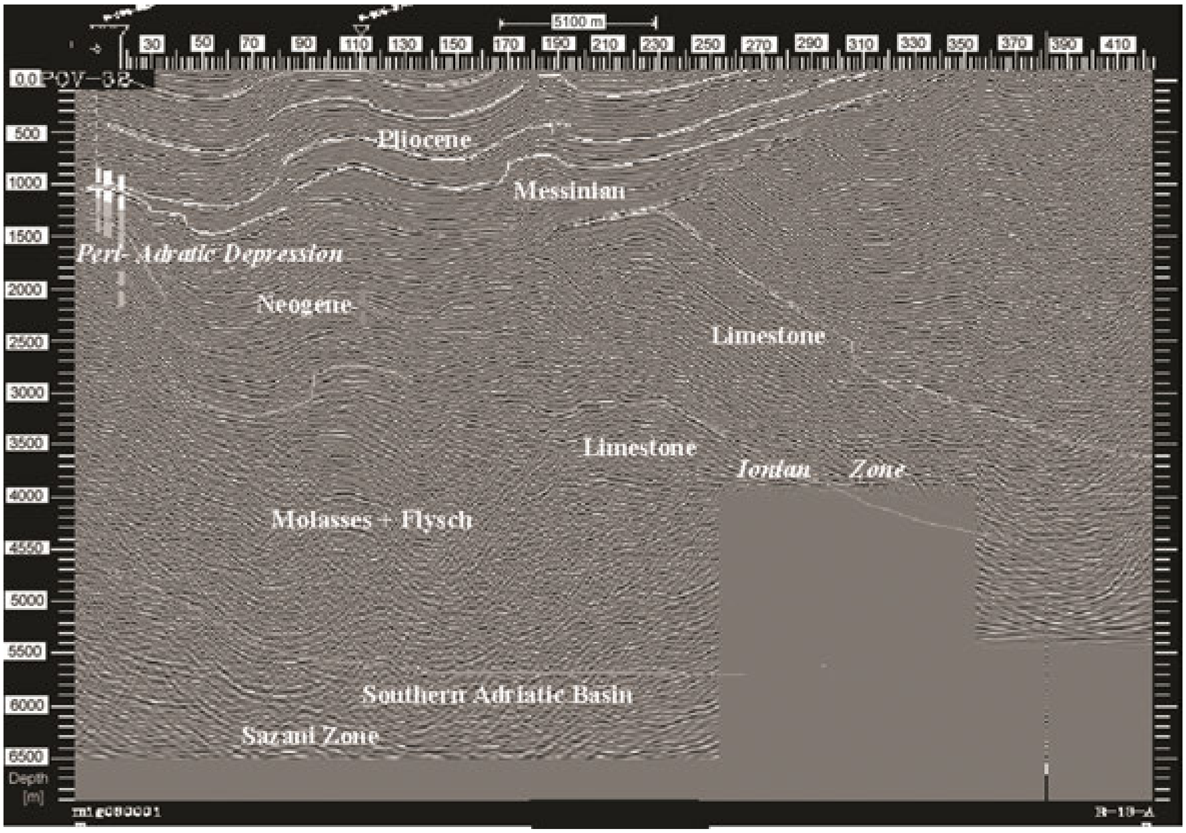

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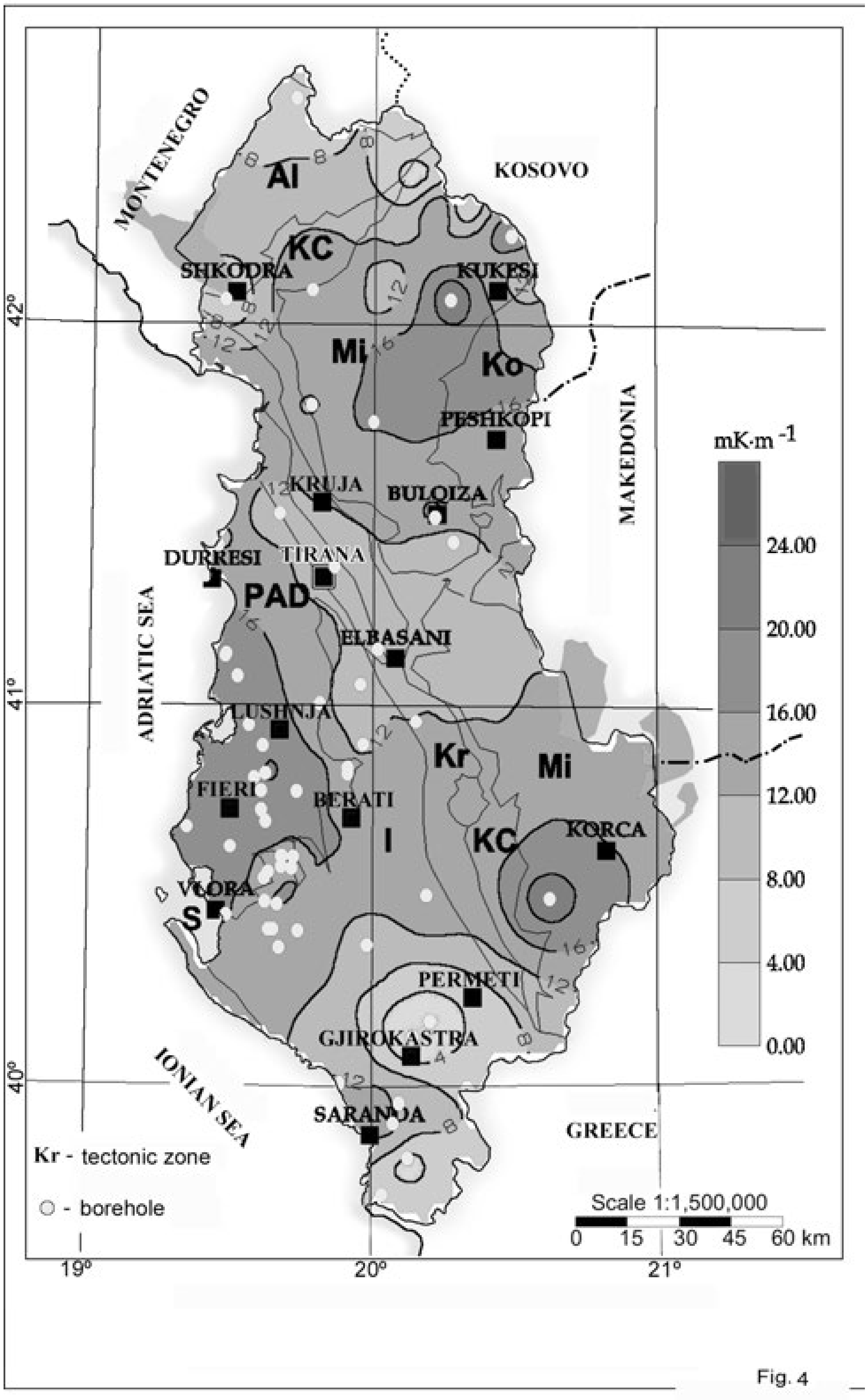

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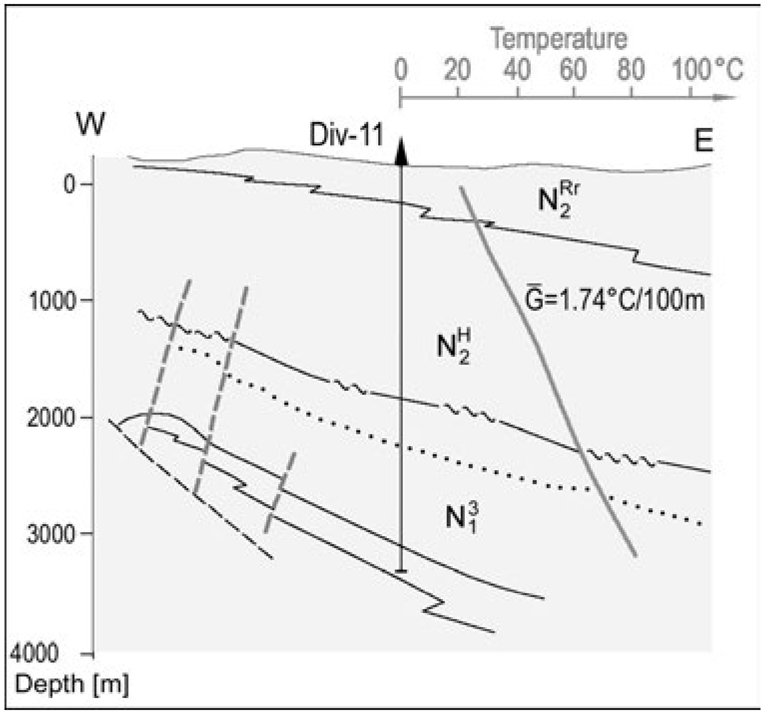

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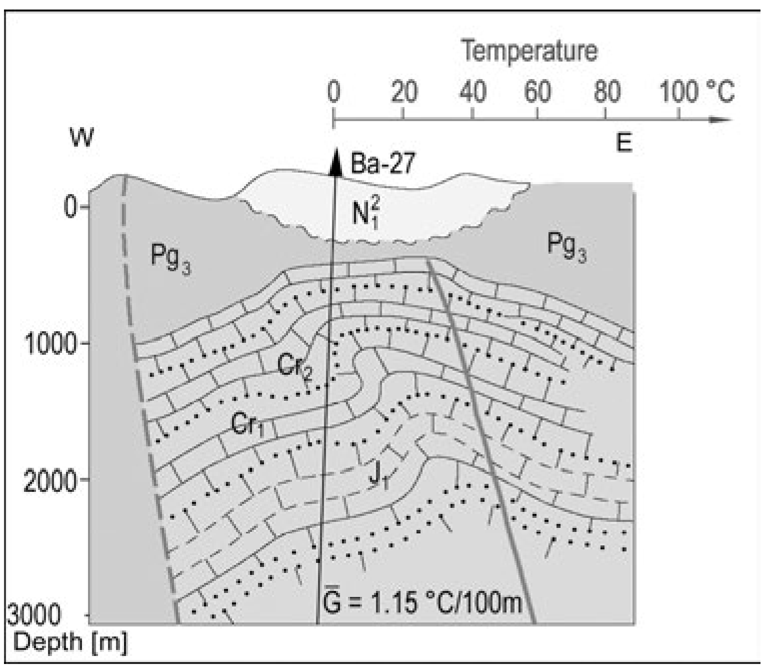

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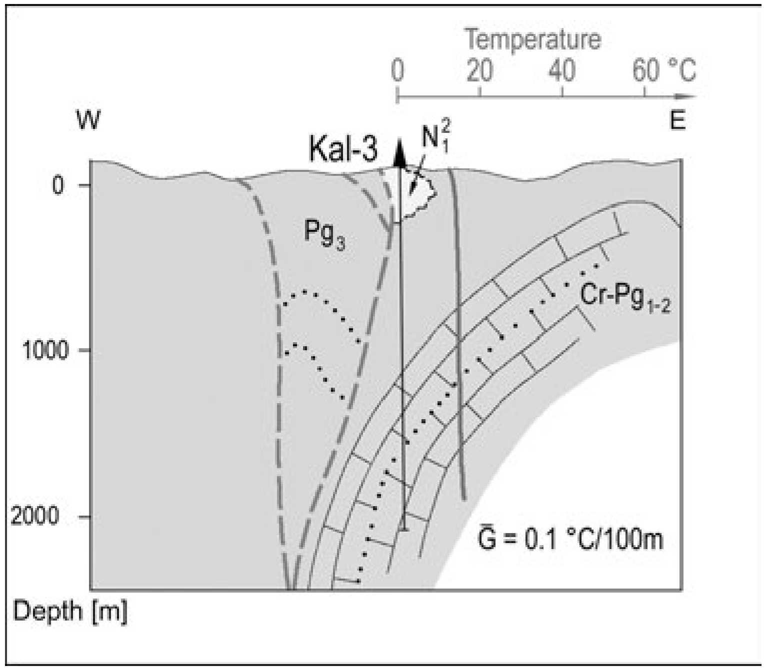

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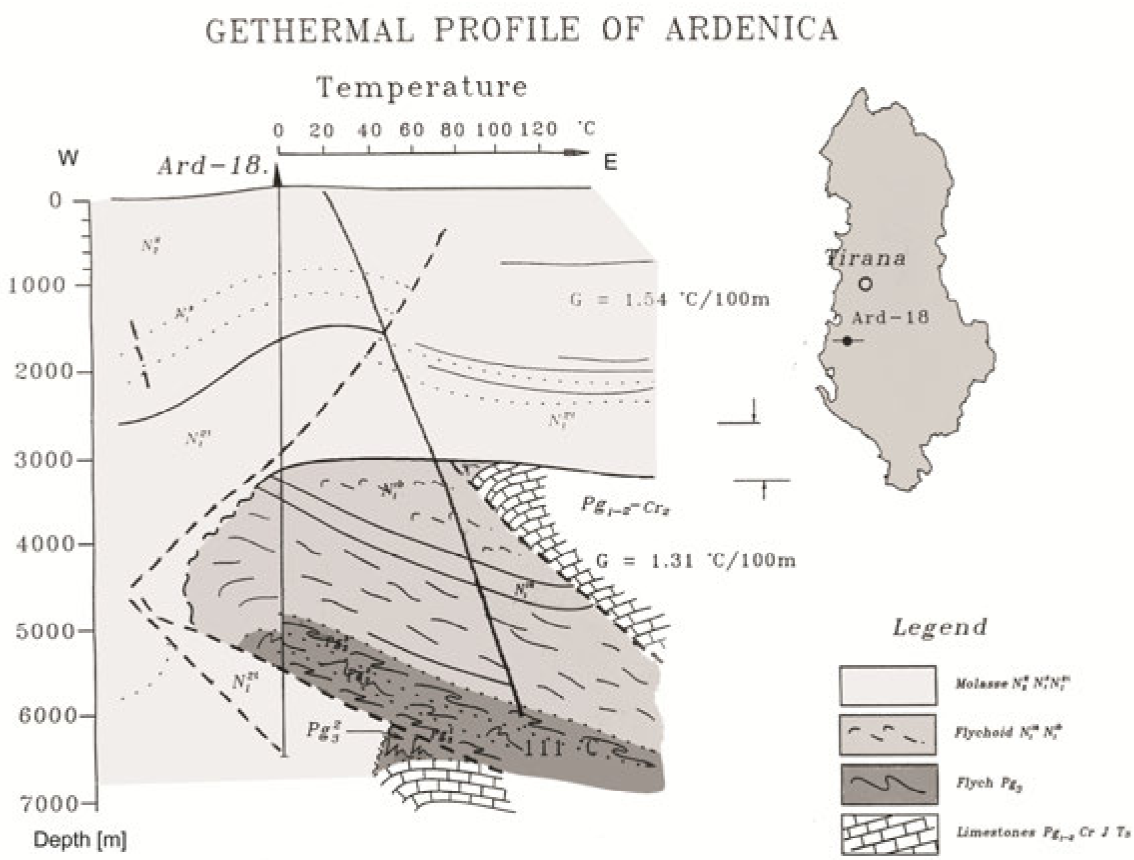
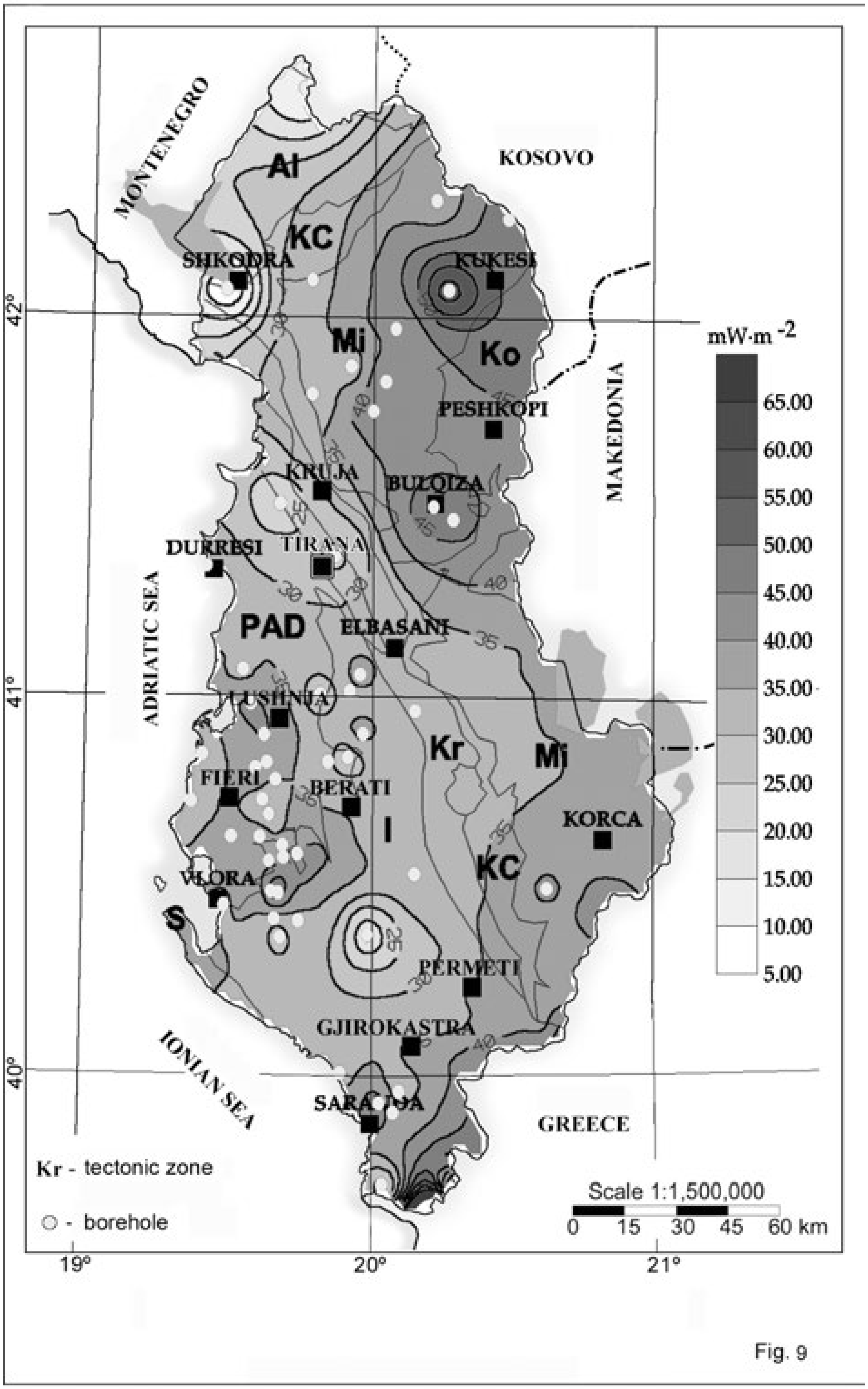


Fig. 8. Geothermal profile, Ardenica Molasse struture



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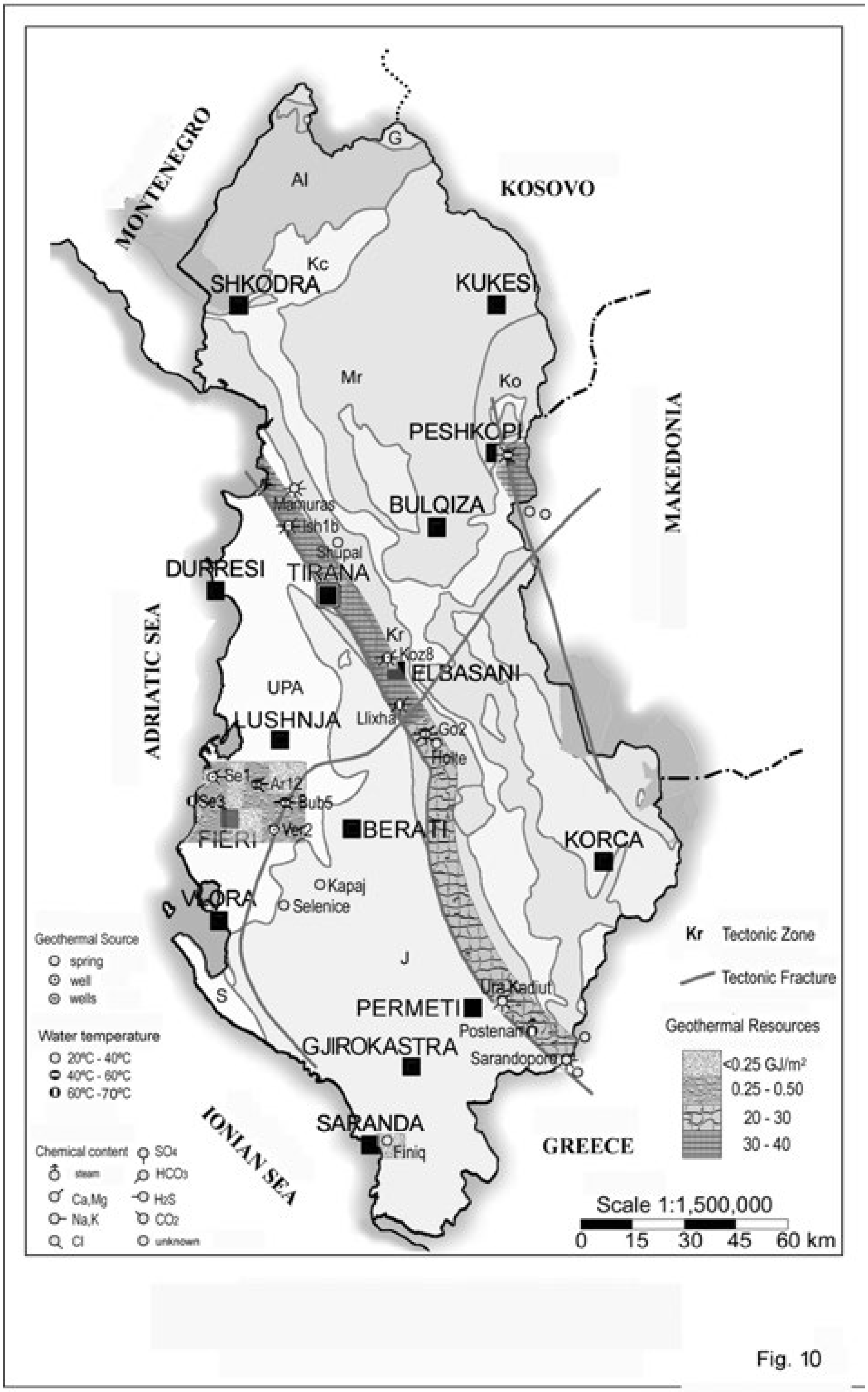

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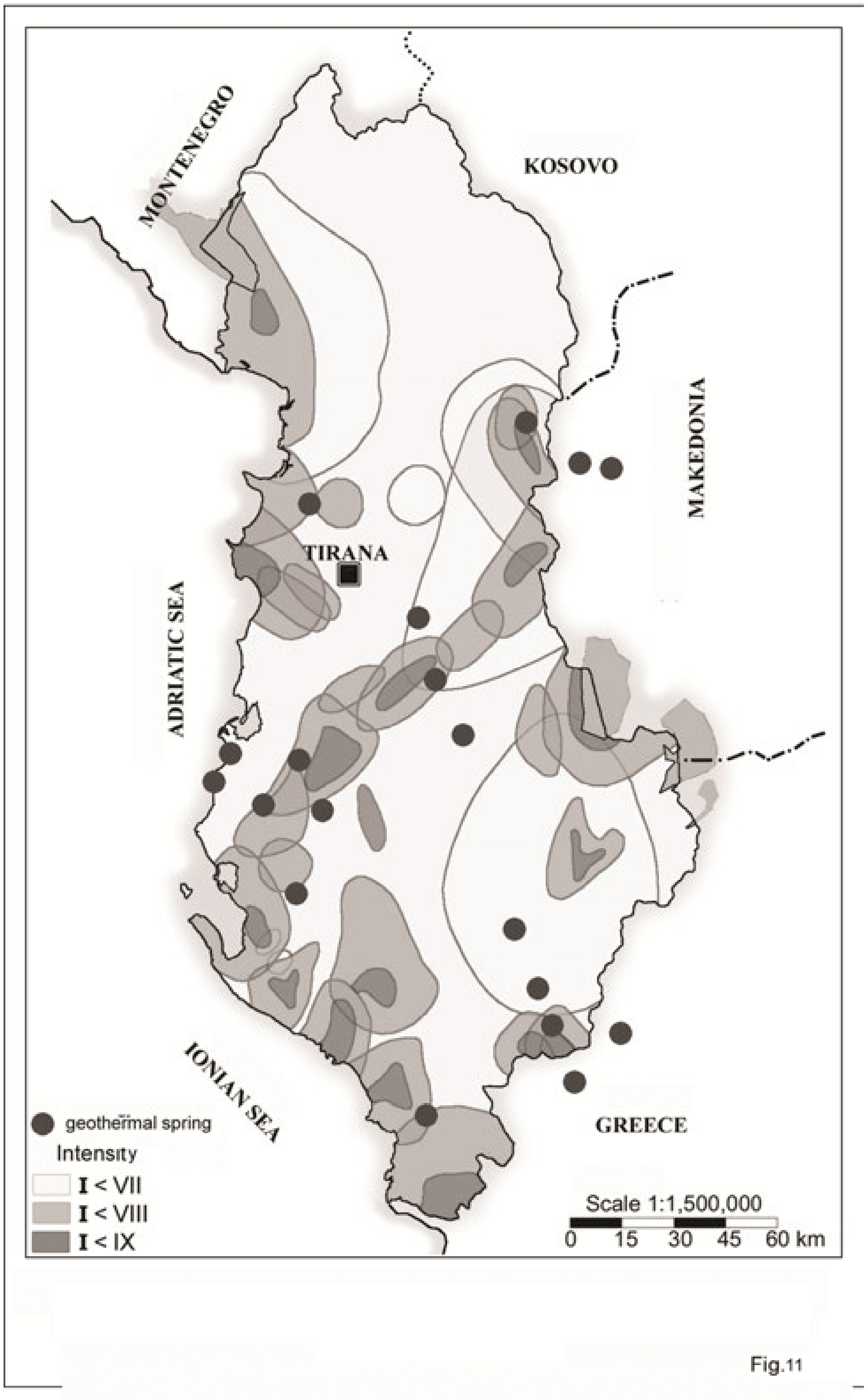

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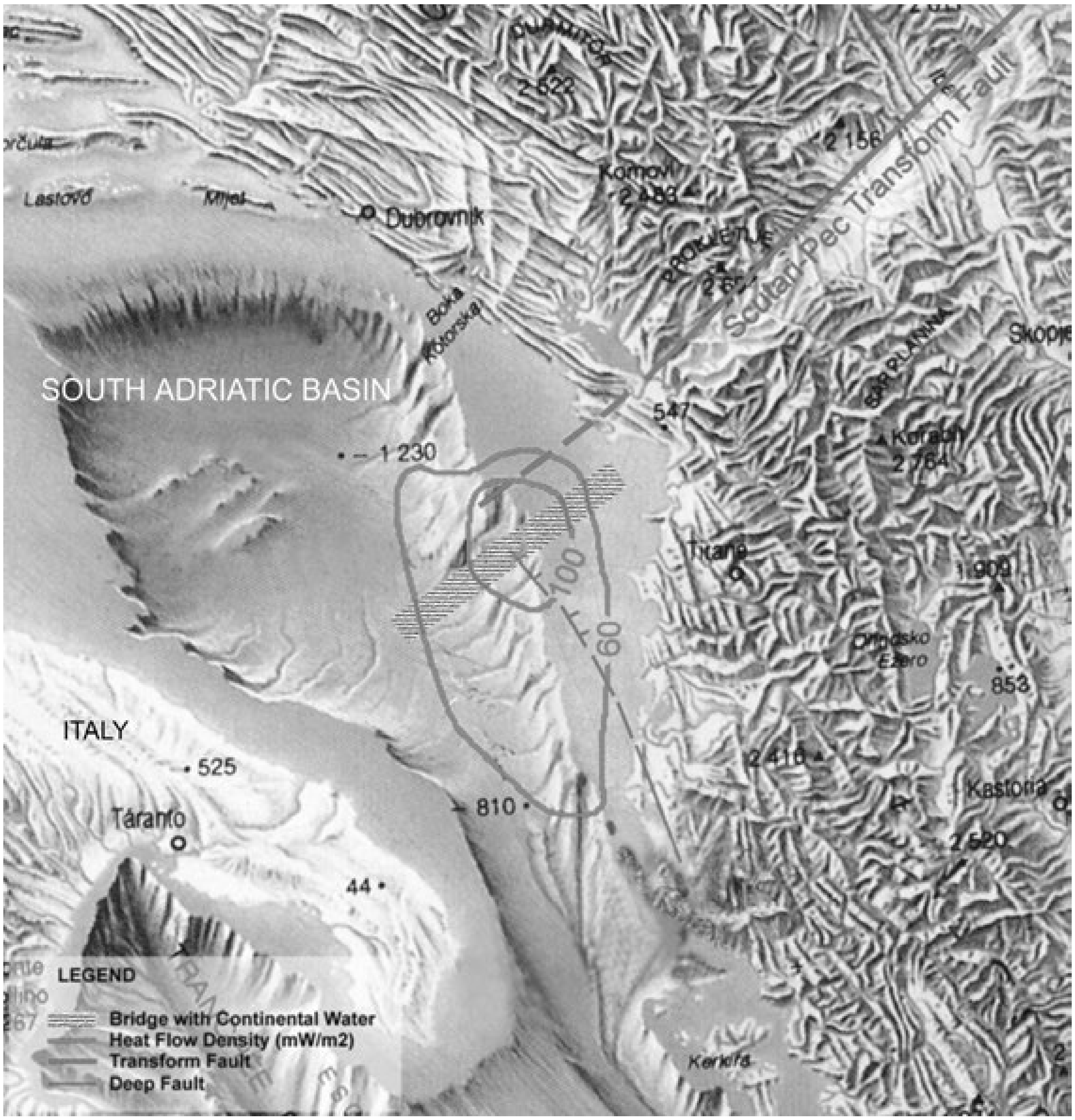

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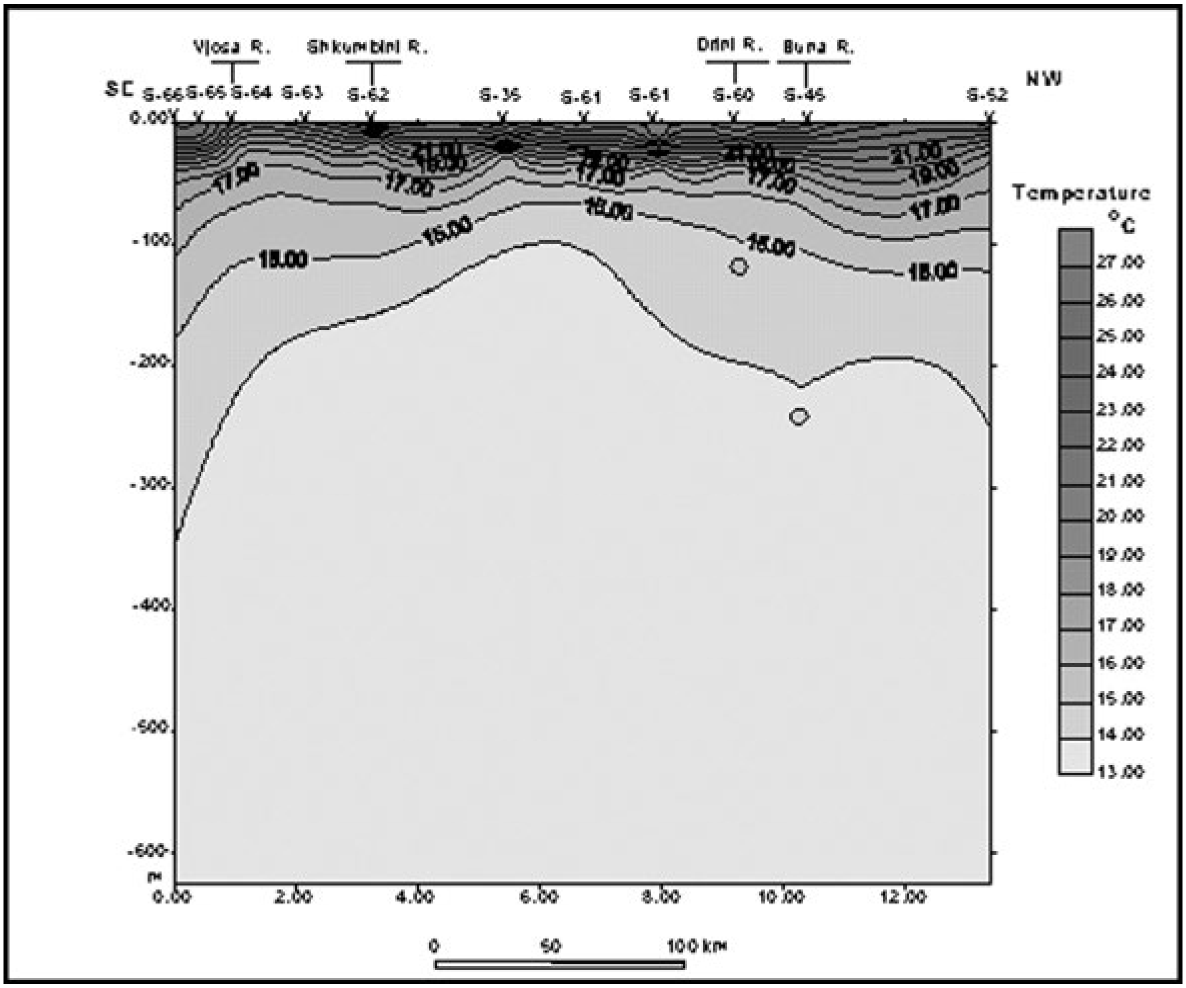

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ALBANIDES A TYPICAL PART OF THE ALPINE MEDITERRANEAN FOLDED BELT, IN THE LIGHT OF THE GEOPHYSICAL STUDIES

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The Albanides represents the assemblage of the geological structures in the territory of Albania. In the paper are presented the structural analysis of the Albanides according to the seismological, reflection seismic, gravity, magnetic, electrical, and geothermal surveys. Two major peleogeographic domains form the Albanides. The Internal Albanides formed part of the Subpelagonian Trough. The External Albanides was developed out of the western passive margin and continental shelf of the Adriatic plate. Regional gravity anomalies and seismological studies results are interpreted as caused by the variation of the depth of Moho discontinuity, and a block construction of the crust. The Earth crust in Albanides is interrupted by a system of longitudinal fractures in NW - SE direction and transversal fractures. Intensive Bouguer anomalies and turbulent magnetic field with weak anomalies characterize ophiolitic belt of the Internal Albanides. These data show about the allochton character of ophiolites. The relations between the Internal and the External Albanides have a nape character, going toward S-W. A joint characteristic of structural belt of Ionian and Kruja zones in External Albanides is their westward thrusting, too. Two tectonic styles are observed in the Ionian tectonic zone: duplex and imbricate tectonic. Miocene and Pliocene molasses of Peri-Adriatic Depression cover Western part of Ionian zone.

Interpretation of the results of integrated geophysical surveys, in the framework of geological studies is presented in the paper.

INTRODUCTION

Integrated regional geophysical studies have been performed for exploration of the Albanides, on land and in the Adriatic Sea Continental Shelf. Seismological studies, gravity and magnetic surveys, reflection seismic lines, geothermal studies, radiometric investigations, vertical electric soundings and well logging are represented applied complex of the geophysical investigation. Interpretations of the geophysical studies result have realized on the base of regional geological studies. Only part of all regional geophysical and geological literature, which we have consulted, is presented in the reference paragraph.

The Albanides represents the assemblage of the geological structures in the territory of Albania, and together with Dinarides at the North and Hellenides at their South are formed the southern branch of the Mediterranean Alpine Belt (Fig. 1), (Aubouen. and Ndojaj, 1964, Aubouen 1973, Biçoku and Papa1965, Biçoku 2000, Bushati 1988, Frasheri et al. 1998, I.G.S. 1983, 1985, Meço and Aliaj 2000, Melo, 1986, Papa 1970). In the paper are presented the structural analysis of the Albanides according to the seismological, reflection seismic, gravity, magnetic, electrical, and geothermal surveys, in the framework of the integrated interpretation with geological observations.

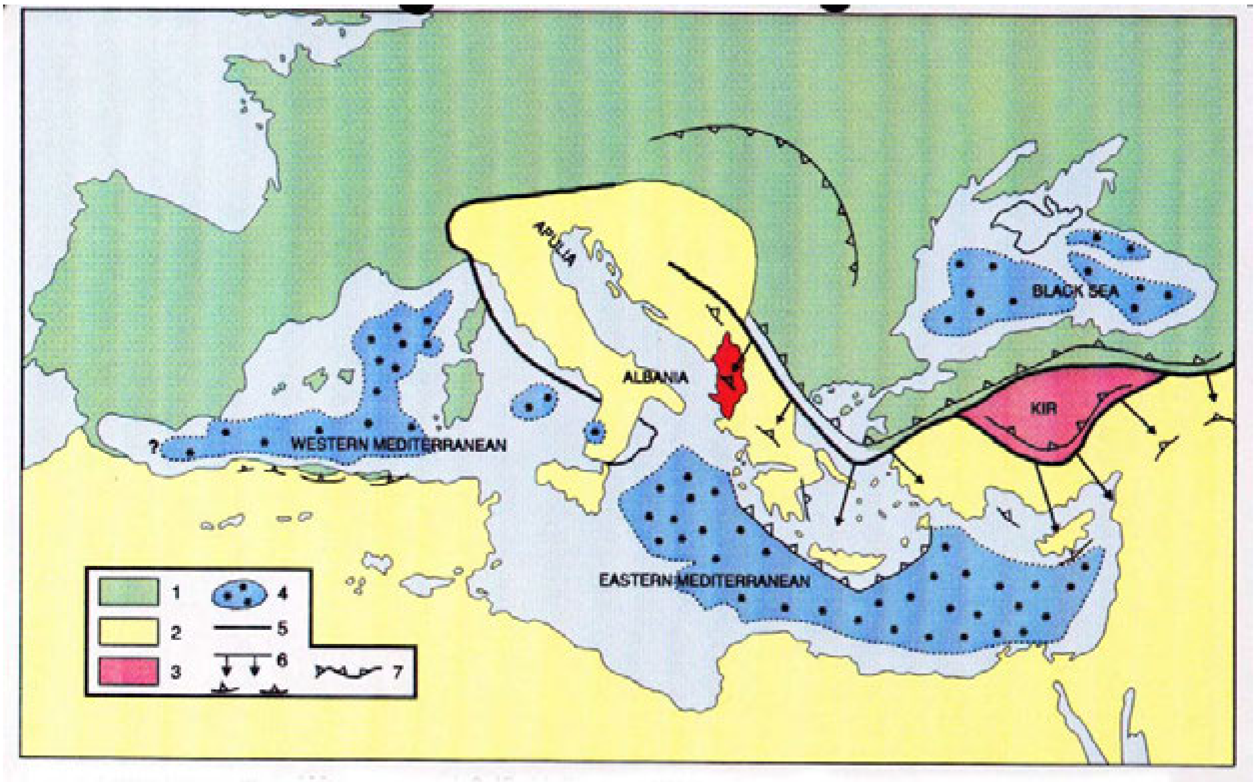


Fig. 1. Schematic Map of African Plate Subduction under the Euroasiatic one

(After Ricou, El. 1986)

1- Euro-Asiatic Continent; 2- African continent; 3- Kishir block; 4- Presents Oceanic Basins; 5- Boundaries of Mesozoic Oceans; 6- Boundaries of Mesozoic Ocean and the Main Ophiolitic Nappes; 7- Troughs of present and past subduction.

Two major peleogeographic domains form the Albanides: the Internal Albanides in the eastern part and the External Albanides in the western part of Albania (Fig. 2).

The Internal Albanides formed part of the Subpelagonian Trough. The Internal Albanides are characterized by presence of the immense and intensive tectonised ophiolitic belt, which is displaced from east to west as overthrust nappe. Internal Albanides has been affected by the paleotectonic stage. There are two viewpoints about the placement of the ophiolites: Allochtone character of the ophiolitic nappe (Auboin 1973, Cadet et al. 1980, Çollaku et al. 1992, Frasheri et al. 1995, 1996, Frasheri 2000, Hoxha et Bushati 1996, Hoxha 2001, Hoxha et Avxhiu 2000, Lubonja et al. 1968, Langore et Bushati 1985, Melo 1986, Papa 1993, Qirinxhi 1970, Veizaj and Frasheri 1996) and autochthon ophiolitic belt (Beccaluva et al. 1994, Gjata et al. 1999, Gjata 2000, Kane et al. 1999, Kodra 1987, 1988, Kodra al. 1996, 2000, Robertson and Shallo 2000, Shallo et al. 1989). Tectonic development of the Internal Albanides has been during Triassic and Jurassic (Kodra A. 1987).

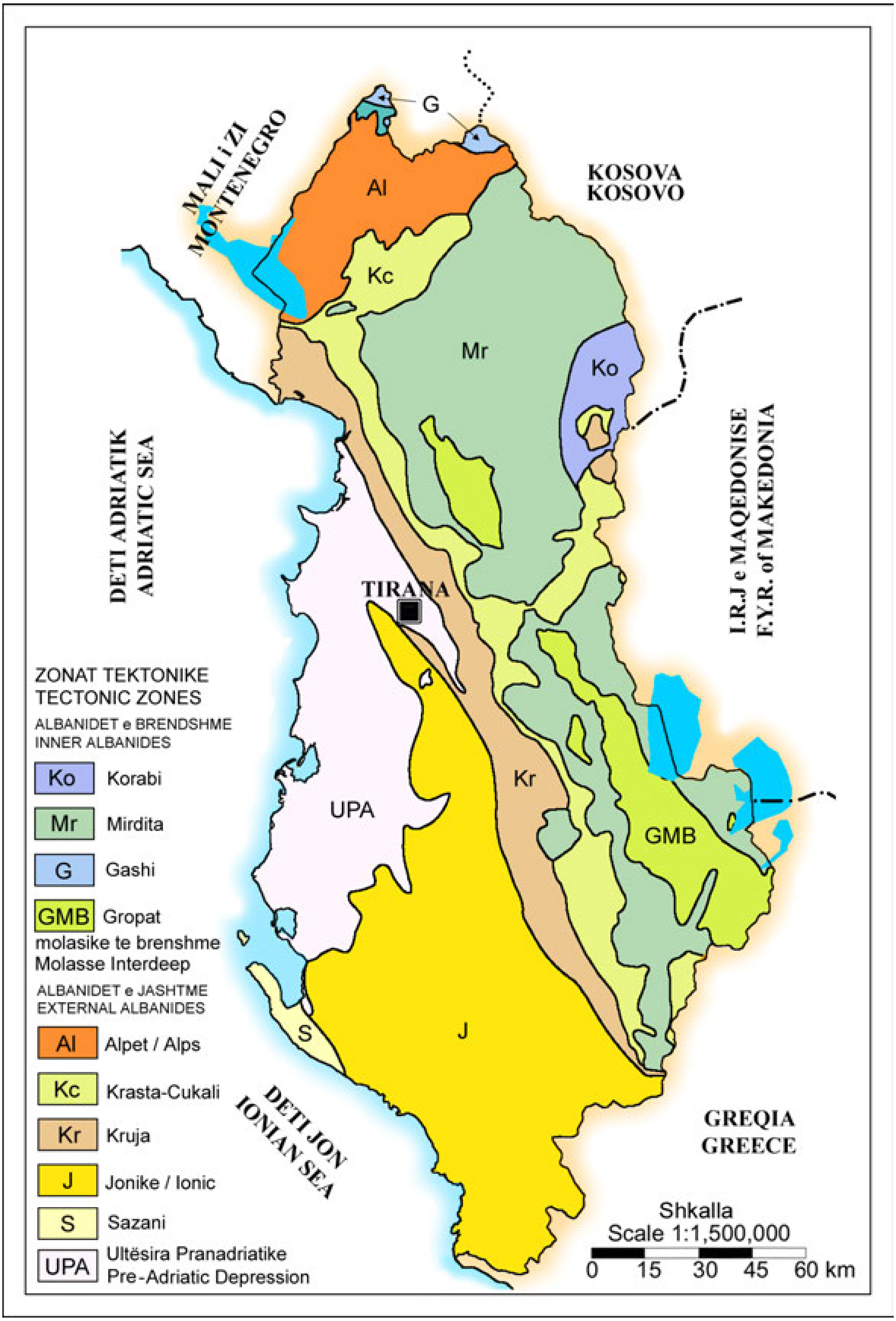


Fig. 2. Schematic Tectonic Map of Albania.

The External Albanides was developed out of the western passive margin and continental shelf of the Adriatic plate. The External Albanides are affected only by the later paleotectonic stages, and are characterized by regular structural belts, which are associated with thrust and over tectonic. Geophysical data reveal that the Earth crust becomes thicker from central regions of Adriatic towards Albanides in land (Bare et al. 1996, Dalipi 1985, 1987, Dhima et al. 1996, Guri et al. 1996, Mëhillka et al. 1996, 1999, Nishani 1985, Papa et Kondo 1968, Seitaj et al. 1996, Valbona et al. 1997, Velaj 1999, Xhufi et al. 1999).

The sedimentary crust has 8-9 km thick in Adriatic seashore and reaches up to 15 km in northwestern regions of Albania (Fig. 3), (Frasheri et al. 1998, 2000, Koçiu 1987, Veizaj 1995, Veizaj and Frasheri 1996. The depth of Moho discontinuity is 40 -50 km. Its deepest part is in northwestern part of Albania. Regional gravity anomalies are interpreted as caused by the variation of the depth of Moho discontinuity, and a block construction of the crust, which coincides fully with the results of seismological studies (Fig. 3, 4). The Earth crust in Albanides is interrupted by a system of longitudinal fractures in NW - SE direction and transversal fractures, that touch even the mantel. Some of them separate even the tectonic zones. This tectonic construction of the deep levels of the earth crust in Albanides finds its reflection even in the scattering of the magnetic fields.

Geological and geophysical regional studies, based on facial-structural criterion, were distinguished some tectonic zones (Fig. 2):

In Albanides	*equivalent in Hellenides and*	*in Dinarides*
Internal Albanides		
Korabi	Pelagonian	Golia
Mirdita	Subpelagonian	Serbian
Gashi		Durmitor
External Albanides		
Albanian Alps	Parnas	High karst
Krasta-Cukali	Pindos	Budva
Kruja	Gavrovo	Dalmate
Ionian	Ionian	
Sazani	Preapulian	
Peri Adriatic Depression		

Intensive Bouguer anomalies and very turbulent magnetic field, with weak anomalies (Bushati 1988, 1997) (Fig. 5, 6, 7), characterize ophiolitic belt of the Mirdita tectonic zone in Internal Albanides. These data shows as follow: Ophiolitic belt has its biggest thickness is about 14 km in its northeastern extreme, in the ultrabasic massif of Kukes (Fig. 8, 10, 11, 12). Towards west and southeast this thickness is reduced up to 2 km. This interpretation shows allochthon character of ophiolite belt and the covering character of the western contact of ophiolitic belt, under which the formation of Krasta-Cukal zone of External Albanides is laid. The relations between the Internal and the External Albanides have a nape character, going toward S-WW direction. The separation of the gravity and the magnetic anomalous belts in the central region of the Internal Albanides, at

Shengjergji flysch corridor, are arguments the presence of Diber -Elbasan - Vlora transversal. This transversal has played a significant role in the geology of Albanides (Fig. 4; 5; 6, 7).

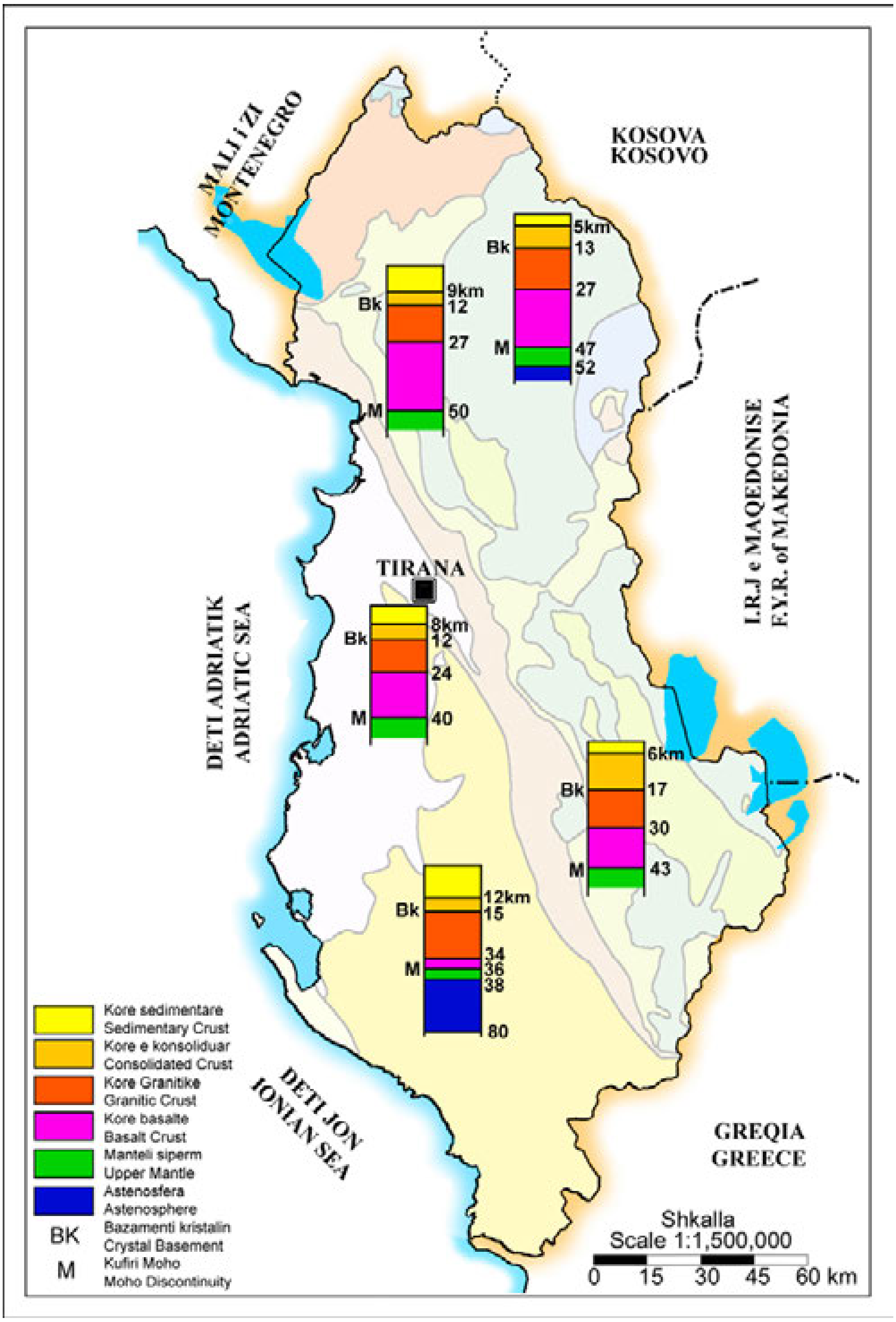


Fig. 3. Geologic structure of Earth's Crust and Upper mantle based on

seismological studies (data taken from Koçiu S. 1989).

The numbers given in legen show the velocity of the seismic waves, in km/s).

1- Sedimentary Crust; 2- Consolidated crust; 3- Granite Crust; 4- Basalt Crust; 5- Upper mantle; 6- Asthenospehere; 7- BK Crystal Basement; 8- Moho Discontinuity.

A joint characteristic of structural belt of Ionian and Kruja zones in External Albanides is their westward thrusting too (Fig. 8, 10, 11, 12). The thrusting process is helped by the presence of the Triassic evaporite sheet under the carbonate section. According to the integrated geological-geophysical studies and deep wells data results that two tectonic styles are observed in the Ionian tectonic zone: duplex and imbricate tectonic. Traversal tectonic faults have separated the Ionian basin in several blocks. Interpreting the limestone top of the south Adriatic basin and Sazani, Ionian and Kruja zones are observed that the southern Adriatic basin limestone partly is extended under the last units. Peri-Adriatic Miocene and Pliocene mosaic deposits cover the Sazani, Ionian and partly Kruja tectonic zones. This Neogene molasses is placed trangressively over the oldest ones up to the limestone of the Ionian zone, creating a two-stage structure (Fig. 20). The molasses post-orogenic deposits were covered transgressively Mirdita and partially Krasta – Cukali tectonic zones in Korça and Burreli basins.

EARTH CRUST CONFIGURATION

Seismological studies and gravity and magnetic survey data have reflected the Earth Crust configuration (fig. 2; 3; 4, 8 and 21), (Aliaj. 1987, Arapi 1982, Bushati 1988, 1997, Chiappini et al, 1996, Duka et al, 1991, Frasheri et al. 1998, 2000, Koçiu 1989, Langora et al. 1983, Lubonja et al. 1968, Lulo et Bushati 1999, Sulstarova 1987, Veizaj 1995, Veizaj et Frasheri 1995. The structure of the Earth Crust according to the refraction seismic is presented in fig. 2. Rocks with a seismic wave velocity of 5.9- 6.2-km/sec present lower layer of the sedimentary crust. These rocks have a much consolidated structure. The regional gravity trend in Albanides is reflected in the influence of the Moho discontinuity. From Eastern part of the Albanides to the Adriatic Sea Shelf, generally it is observed an increasing of the gravity force (Fig. 5, 8 and 21). In the geological-geophysical profiles Albanid 1 and Albanid-2 (Fig. 8 and 21) is presented the decreasing of the depth of roof of the Moho discontinuity of the Adriatic Sea region. The Moho discontinuity plunges from 25 km in the central part of the Adriatic Sea (Finetti. and Morelli, 1972) to 43- 52 km at eastern part of Albanides. According to the interpretation of the magnetic regional anomalies resulted that top of the crystal basement plunged toward the littoral of the Albanides up to central areas of the Albania (fig. 8 and 24).

In the Albanides are fixed four third order trend of Bouguer anomalies of the low order: two maximums two minimums (Fig. 5, 6). Main gravity maximum is extended over the northeastern part of Mirdita tectonic zone and that of Korabi. Second maximum is located at Vlora district, in southwestern part of Albania. It is very important observation that this maximum has a strike sub-transversal with geological structures of the Ionian tectonic zone. These regional gravity maximums are attributed to a crust thinning toward the Mirdita tectonic zone and in Vlora district (Fig, 8, 21). The same phenomenon is observed in the south of ophiolitic belt of Mirdita tectonic zone to the Hellenides (Cadet et al. 1980). Main gravity minimum is extended from southeastern region of Albania to the northwestern littoral of Albania. Second minimum is located at Alps tectonic zone, by a strike in the SE-NW direction.

These anomalies are interpreted as caused by the vacillation of the depth of roof of Moho discontinuity, and reveal a block construction of the crust, which coincides, fully with the results of seismological studies (fig.2). This tectonic construction of the deep levels of the earth crust in Albanides finds its reflection even in the scattering of the magnetic fields (fig. 7).

The Earth crust in Albanides is interrupted by a system of longitudinal fractures in NW - a SE direction and transversal fracture that touch the mantel (fig.6). Some of them separate even the tectonic zones. With deep fractures are linked geothermal energy of the Albanides. According to the geothermometer data results that the water temperature reaches to 220-270oC, in the primary reservoir, where the water has been heated, at the depth 12 – 13 km.

Earth crust setting of the Albanides conditioned the distribution of the geothermal field and energy. In the Heat Flow Density Map of Albania are observed two characteristics (Fig. 9) (Çermak et al. 1996, Frasheri 1993, 2000, Frasheri et al. 1995; 1998, 1999):

Geothermal gradient changes from western to the eastern part of the Albania, and in the depth, too. The gradient values vary from 15-21.3 mK/m in Pre-Adriatic Depression. According to the modeling results, deeper than 20 km is observed decreasing of the gradient. This change of the gradient is coincided with the top of the crystal basement. In the ophiolitic belt of the Inner Albanides, the geothermal gradient at northeaster and southeastern part of the Albania has a value up to 36 mK/m. Decreasing of the gradient are observed deeper than 12 000 meters in this side of Albania, at the top of the Triassic salts deposits (fig. 8). In the both lines are observed that the temperatures in ophiolitic belt are higher than in the sedimentary basin, at the same depth.

In the Heat Flow Density Map of Albania (fig. 9), is possible to observed two particularities of the scattering of the thermal field of the Albanides:

Firstly, 42 mW/m^2 is maximal value of the heat flow in the External Albanides. At the eastern part of Albania, the heat flow density values are up to 60 mW/m^2. Radiogene heat generation of the ophiolites is very low. In these conditions, increasing of the heat flow in the ophiolitic belt, are linked with heat flow from the depth. According to the Alb-1 line, the granites of the crystal basement, which have the possibilities for the great radiogenic heat generation represents the heat source. In ophiolitic belt, is observed decreasing of the Moho discontinuity depth.

Secondly, in the ophiolitic belt are observed some hearth of higher heat flow density. Heat flow anomalies are conditioned by intensive heat transmitting through deep and transversal fractures. These fractures are conditioned location of the geothermal energy sources. According to the calculation of different geothermometers, the aquifer estimated temperatures are 144 to 270^{o}C. Based on the geothermal modeling, one can suppose that thermal waters rise from 8-12 km deep, where temperature attains to 220^{o}C.

These arguments show that crystal basement has a bocks character. Depth of the location f these blocks is shallower in Mirdita tectonic zone. Local heat hearths show the existence of the transversal fractures and through these fractures is very high heat flow. Geothermal energy is linked with great heat flow through these fractures.

The crust setting and their dynamics are reflected in the geology of the tectonic zones of the Albanides, and their tectonic styles.

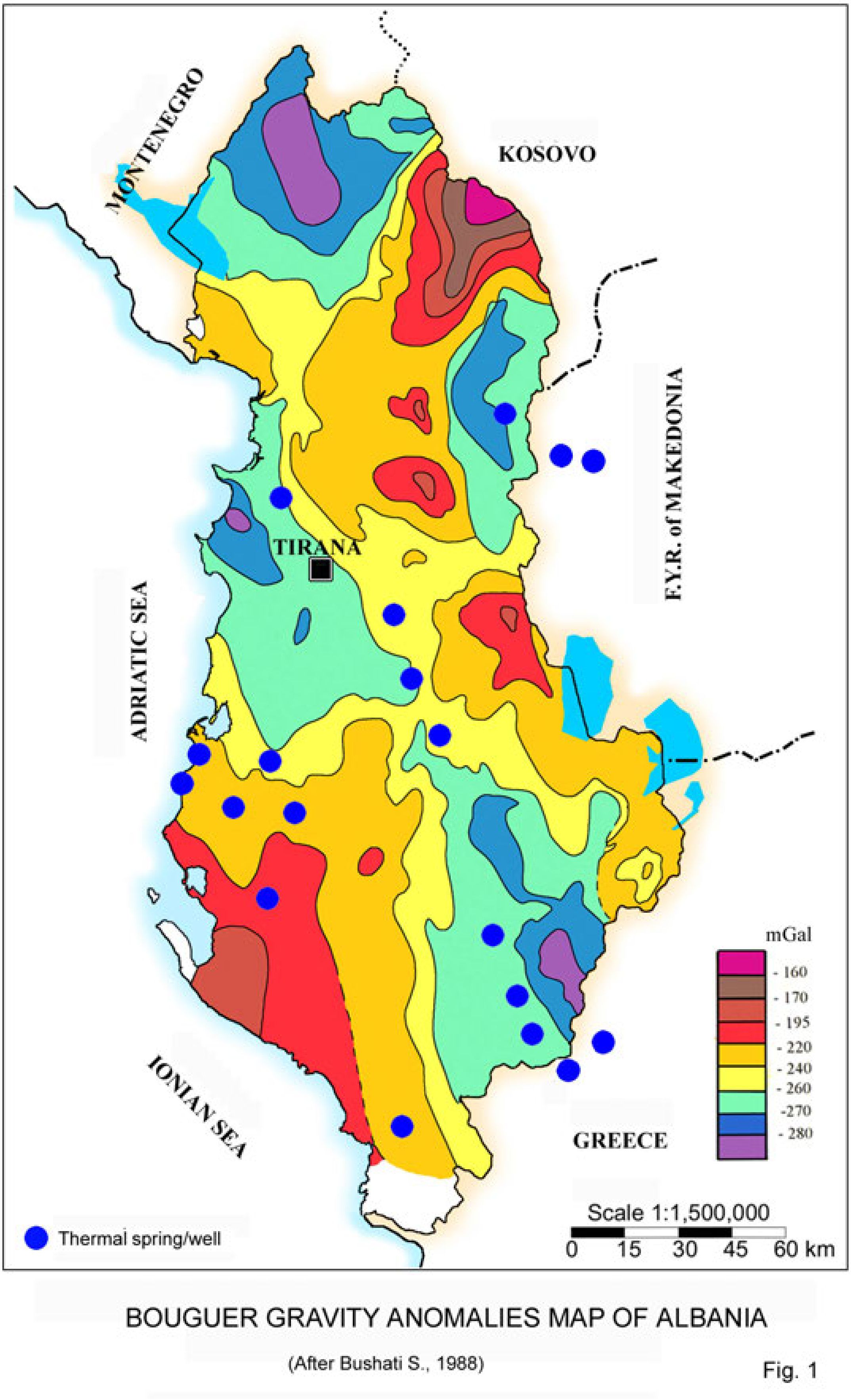


Fig. 4. Bouguer Gravity Map of Albania.

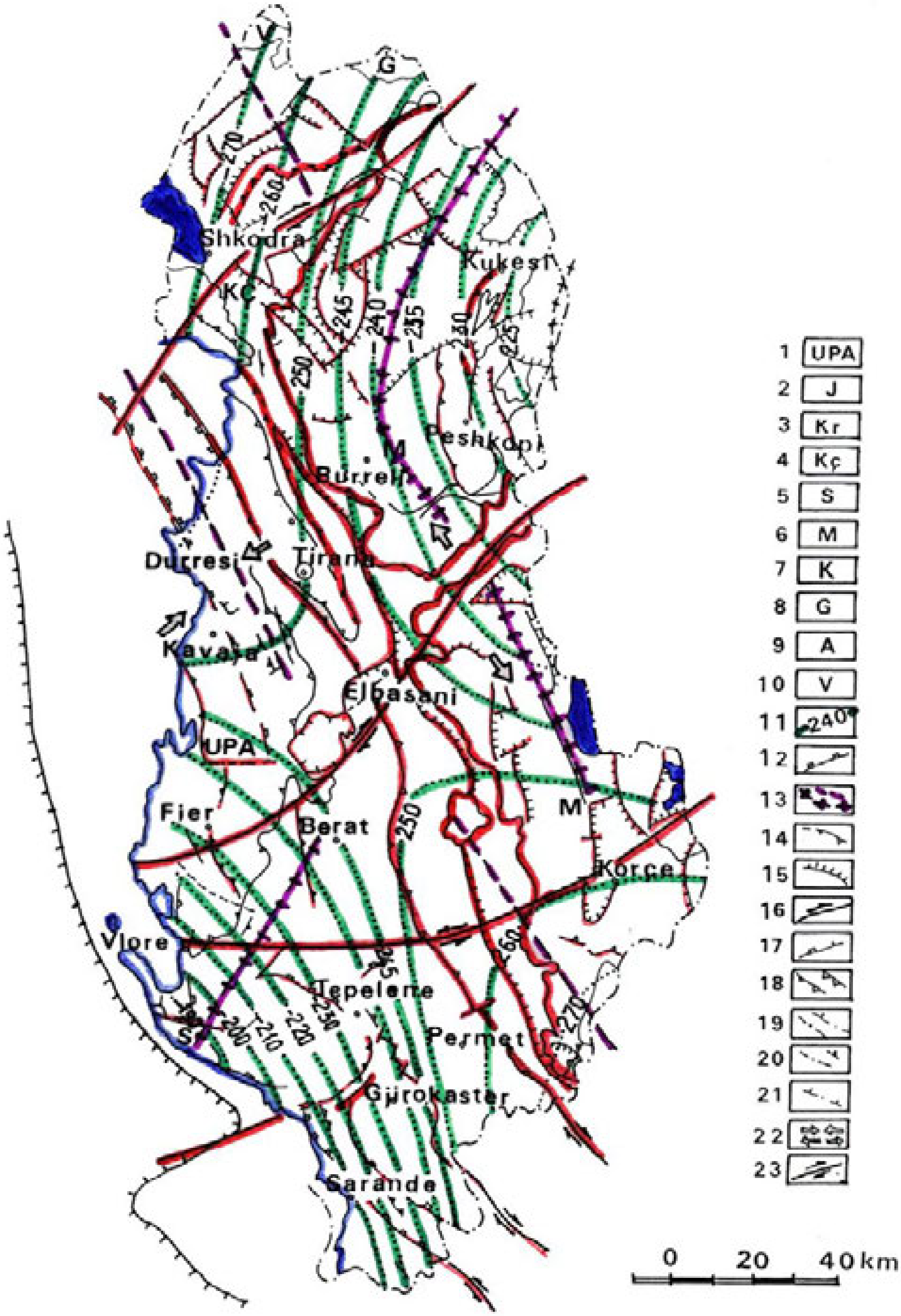


Fig. 5. The Complex Tectonic Map and map of the trend of 3rd degree of Bouguer

Anomaly in the Albanides.

1- Peri-Adriatic Depression; 2- Ionian Zone; 3- Kruja zonw; 4- Krasta-Cukali zone; 5-Sazani zone; 6- Mirdita zone; 7- Korabi zone; 8- Gashi zone; 9- Albanian Alps zone; 10-Vermoshi zone; 11- trend of 3rd degree of Bouguer Anomaly; 12- Boundary between shelf and continental slope; 13- The axes of the up-left and down-left of the Mante; 14-Boundary of the Peri-Adriatic Depression with angular discordance; 15- Normal fault; 16- Pressure; 17- Limit of deformed envelopment during the neotectonic period; 18-Overthrust; 19- Flexure; 20- Flexure and faults based on geophysical data; 21- Inactive overthrust; 22- Compression (a) and (b) extension zones; 23- Deep faults.

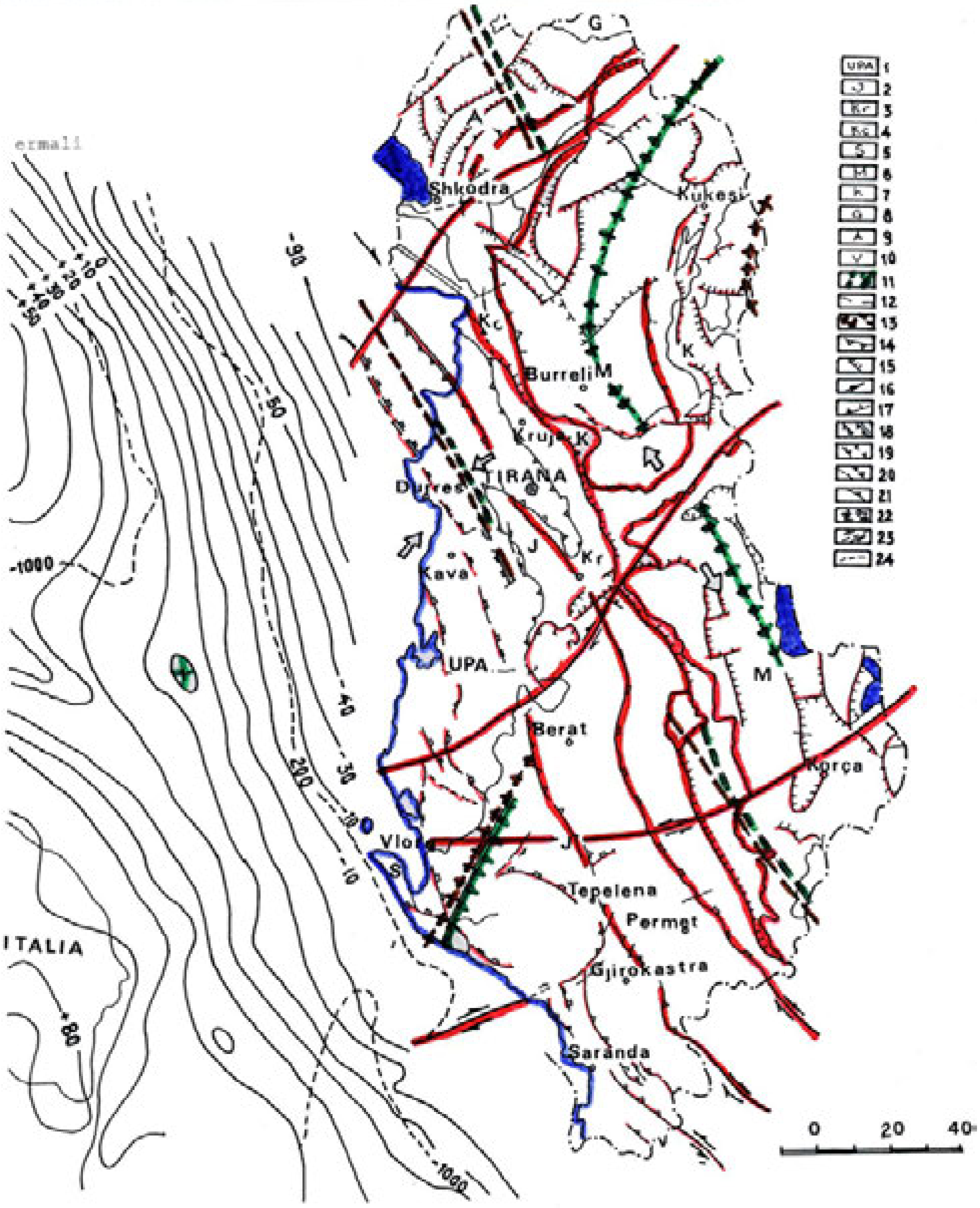
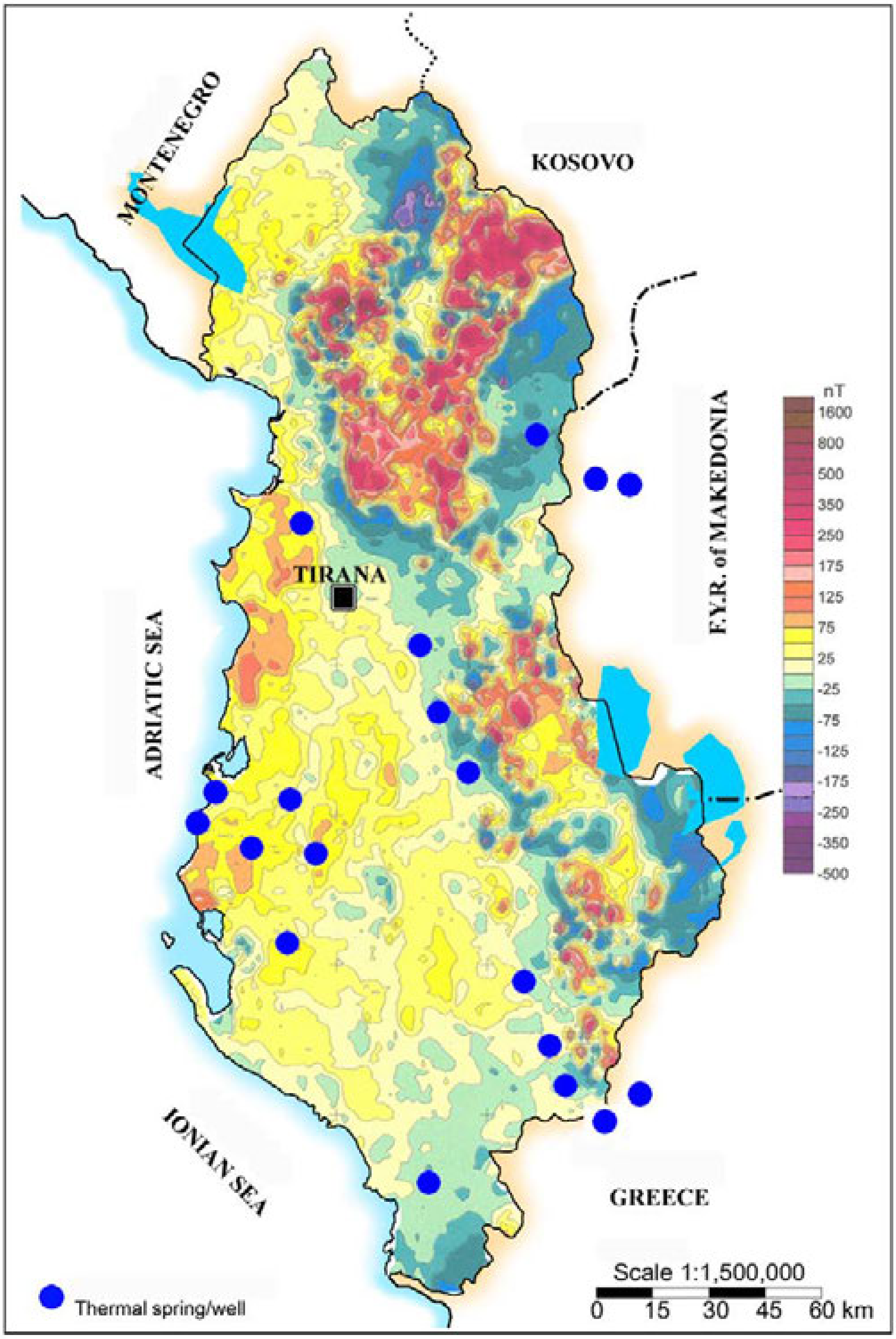


Fig. 6. The Complex Tectonic Map and axes of the Bouguer anomaly in the

Albaniedes and in continental plate of the Adriatic Sea.

1- Peri-Adriatic Depression; 2- Ionian Zone; 3- Kruja zonw; 4- Krasta-Cukali zone; 5- Sazani zone; 6- Mirdita zone; 7- Korabi zone; 8- Gashi zone; 9- Albanian Alps zone; 10- Vermoshi zone; 11- The axes of the Bouguer Residual Anomalies, positive (a) and negative (b); 12- Isoanomals of the Bouguer Anomaly in the Adriatic and Ionian Sea (after Morelli C et al. 1969); 13- The axes of the up-left and down-left of the Mante; 14- Boundary of the Peri-Adriatic Depression with angular discordance; 15- Normal fault; 16- Pressure; 17- Limit of deformed envelopment during the neotectonic period; 18- Overthrust; 19- Flexure; 20- Flexure and faults based on geophysical data; 21- Inactive overthrust; 22- Compression (a) and (b) extension zones; 23- Seismogene deep up-rupt; 24- Isobaths of the water depth, in meters.



TOTAL MAGNETIC FIELD MAP OF ALBANIA
(After Bushati S. 1987)

Fig. 2

Fig. 7

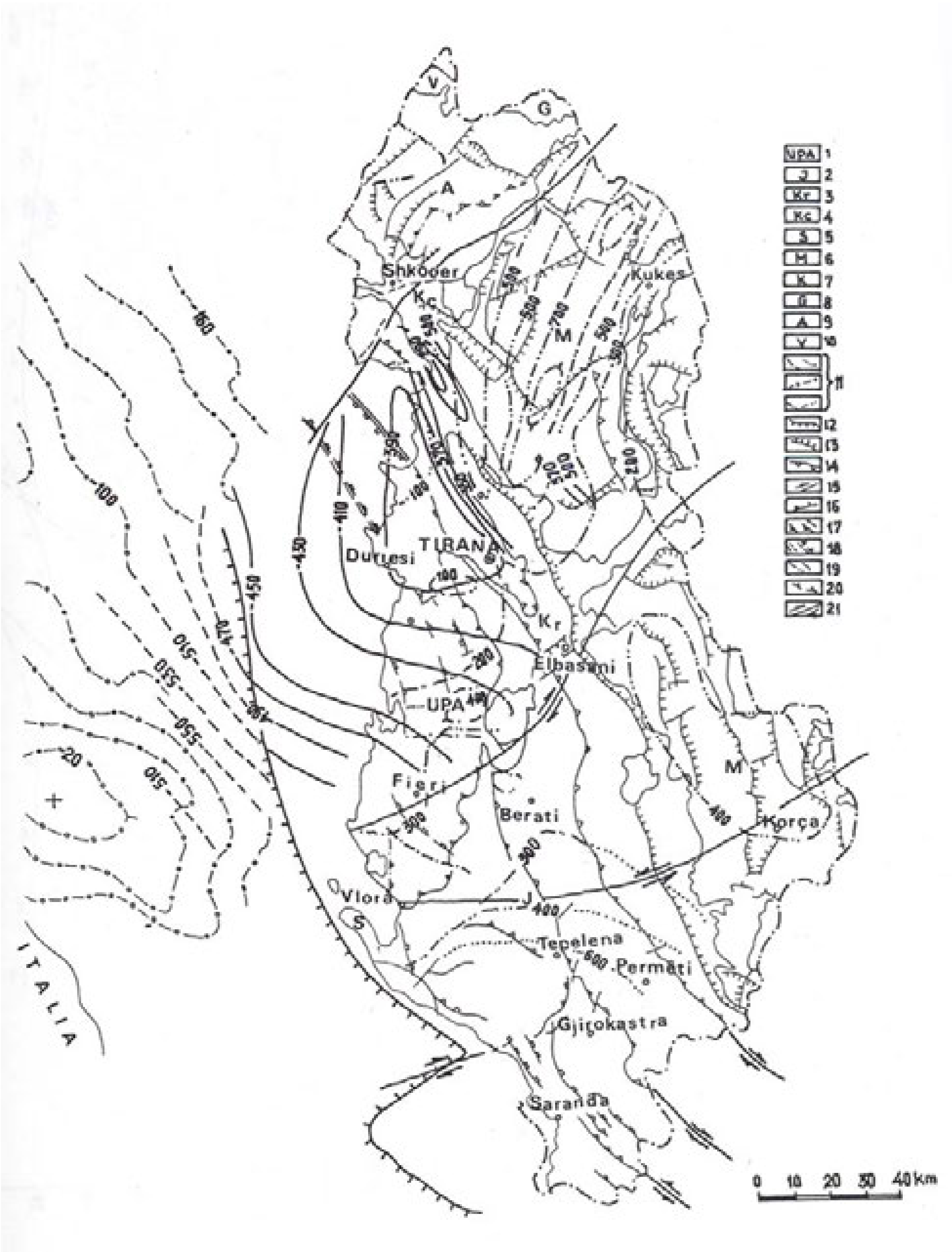


Fig. 7. The Complex Tectonic Map and Total Magnetic anomalies in the Albanides and in

Adriatic Sea continental plate.

1- Peri-Adriatic Depression; 2- Ionian Zone; 3- Kruja zonw; 4- Krasta-Cukali zone; 5- Sazani zone; 6- Mirdita zone; 7- Korabi zone; 8- Gashi zone; 9- Albanian Alps zone; 10- Vermoshi zone; 11- Isoanomals of residual total magnetic anomalies; 12- Boundary between shelf and continental slope; 13- Normal faults; 14- Boundary of the Peri-Adriatic Depression with angular discordance; 15- Pressure; 16- Limit of deformed envelopment during the neotectonic period; 17- Overthrust; 18- Flexure; 19- Flexure and disjunctions based on geophysical data; 21- Inactive overthrust; 22- Depth seismogenic up-rupt.

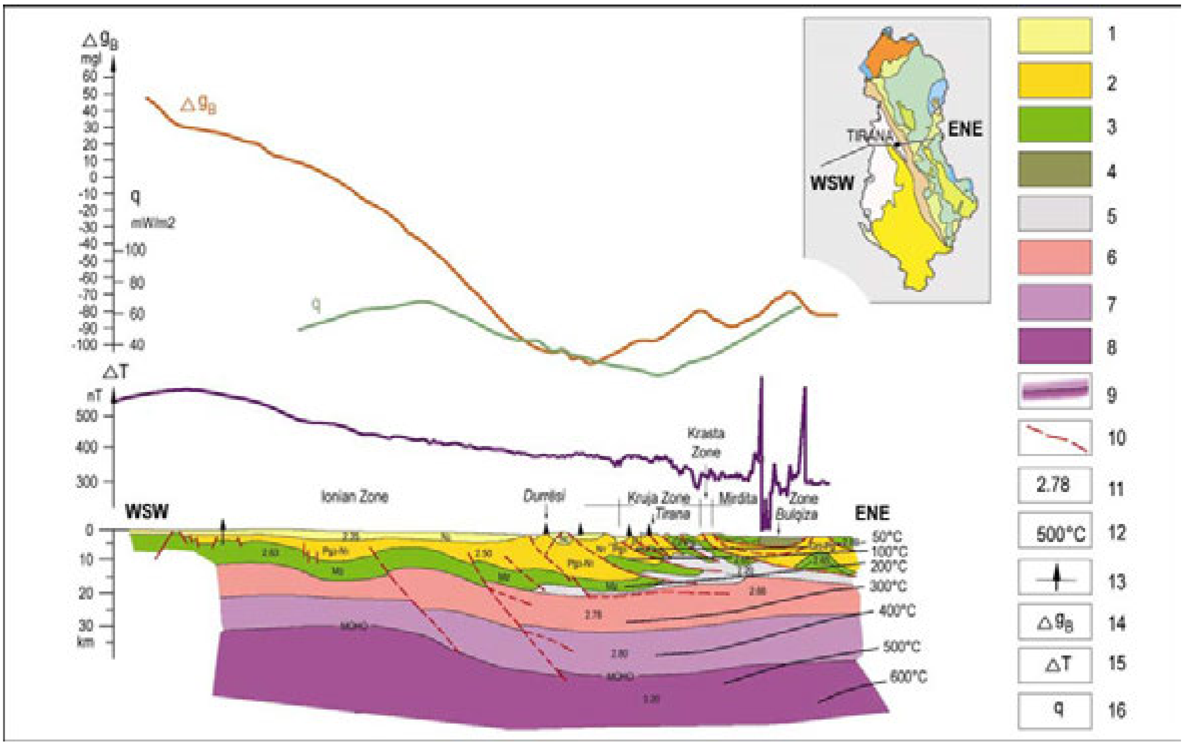


Fig. 8. Geological-geophysical profile Albanid-2: Falco Adriatic Sea- Durres-

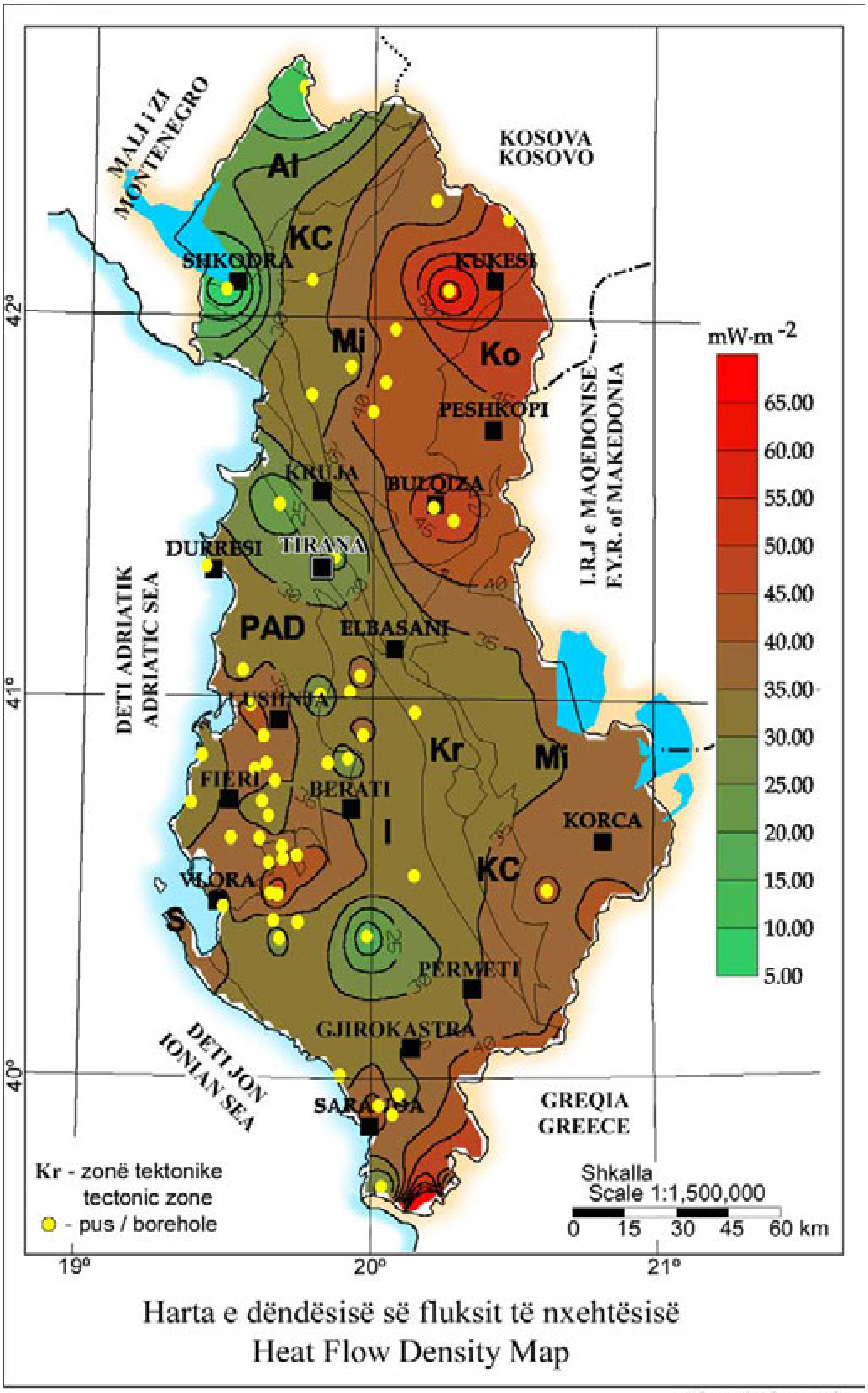
Tirana- Peshkopi (The gravity data for the Adriatic Sea after Richetti, 1980).

1. Pliocene Sustratum; 2- Substratum of Serravalian Molasses; 3- Paleogenic flysch (Pg_3) and molasses over the limestone; 4- Flysch of the Mastrichtian ($Cr^m{}_1$), Lower and Middle Paleogene (Pg_{1-2}); Old flysch of Jurassic (J) and middle Cretaceous (Cr_2); 6- Carbonatic facies divided by the tectonic zones; 7- Ultrabasic rocks; 8- Disjunctive tectonic; 9- Depth up-rupt; 10- Top of chrystal basement; 11- The basal of the Earth Crust; 12- Moho Discontinuity' 13- Focus nodal plan of the earthquakes in the Kavaja region, western Albania; 14- Seismic reflection; 15- Deep well.

   $G_{B,t}$- Trend of 2nd degree of Bouguer anomaly; $G_{B,t}$- Residual Bouguer anomaly;

   T_t - Trend of the 2nd degree of total magnetic anomaly; T_r - Residual of the 2nd

   degree of total magnetic anomaly; T_o - Observed magnetic anomaly;



Harta e dëndësisë së fluksit të nxehtësisë
Heat Flow Density Map

Fleta / Plate 16

Fig. 9

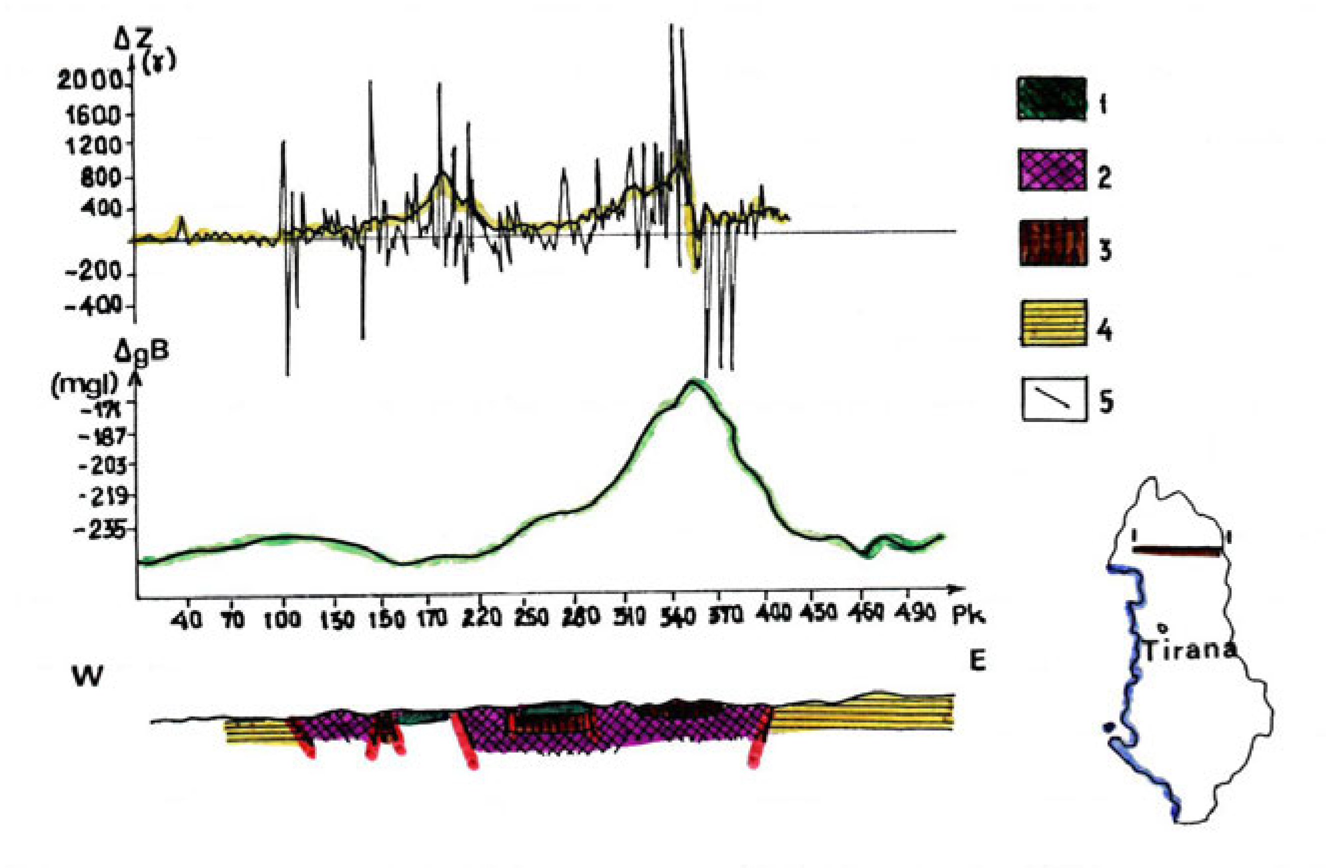


Fig. 10. Geological-geophysical Shkodër-Kukës profile.

1- Effusive rocks; 2- Ultrabasic rocks; 3- Gabbro; 4- Sedimentary formation; 5- Disjunctive tectonic.

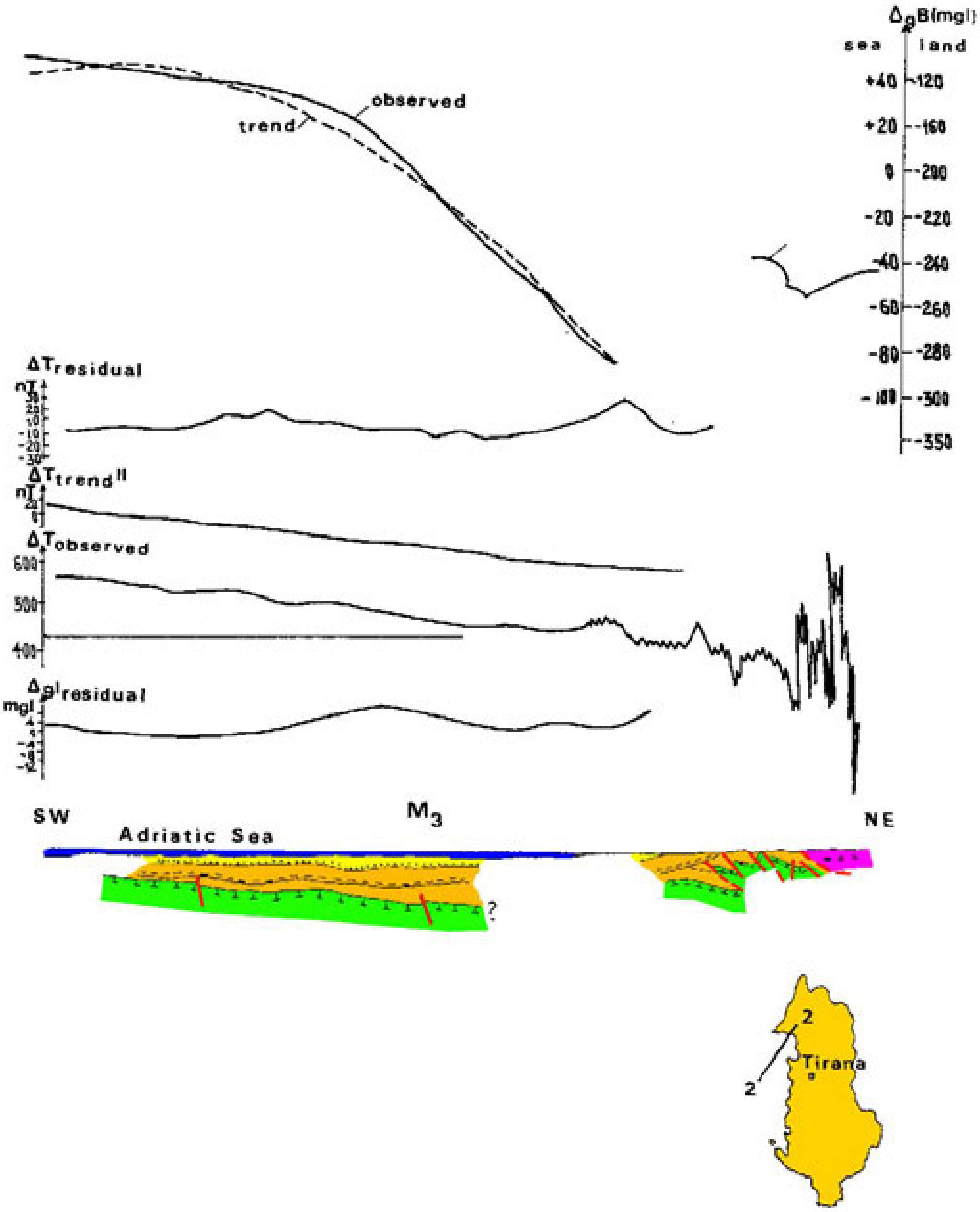


Fig. 11. Geological- geophysical profile: Adriatic Sea- Vrith

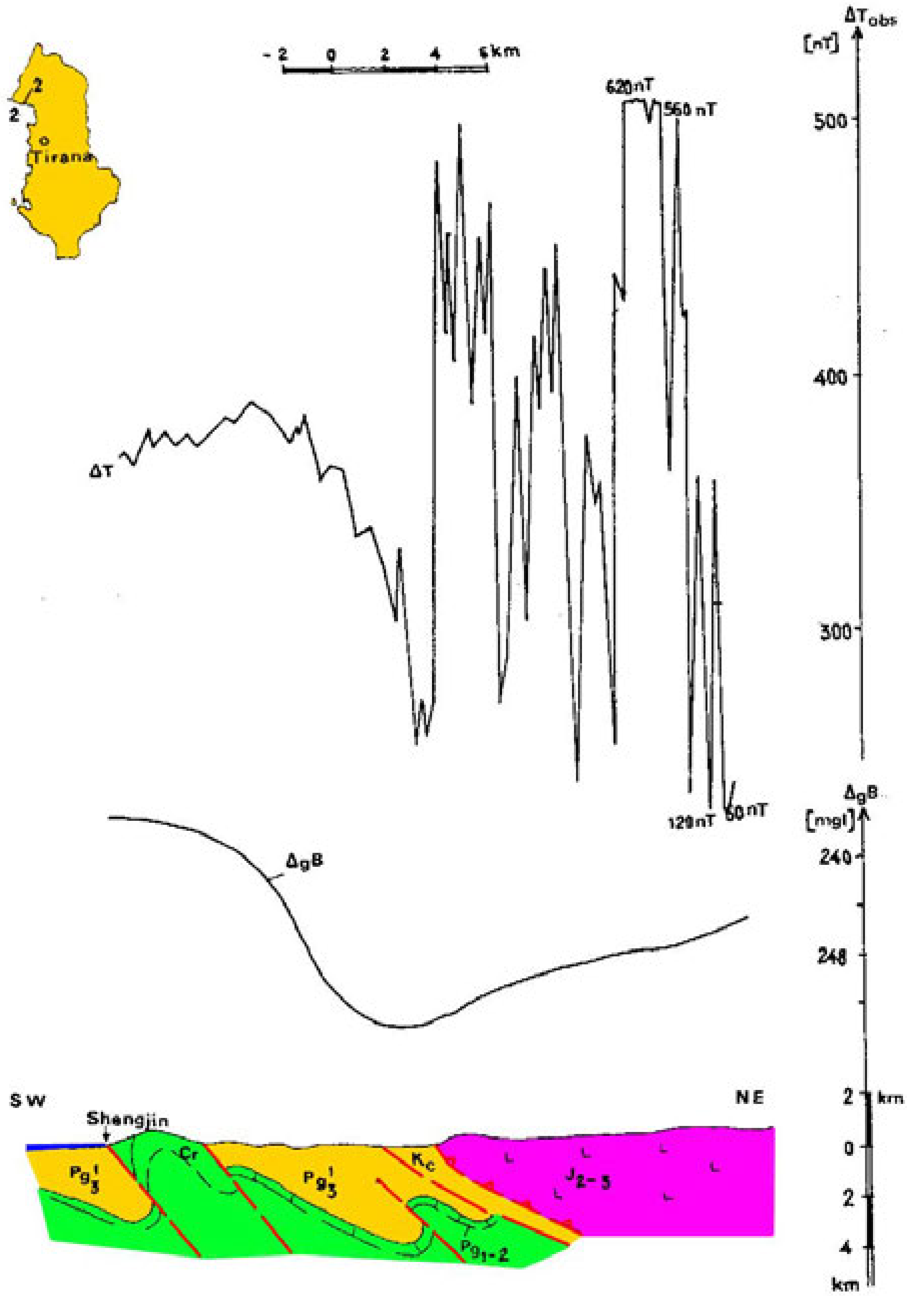


Fig. 12. Geological-geophysical profile: Shëngjin- Vrith.

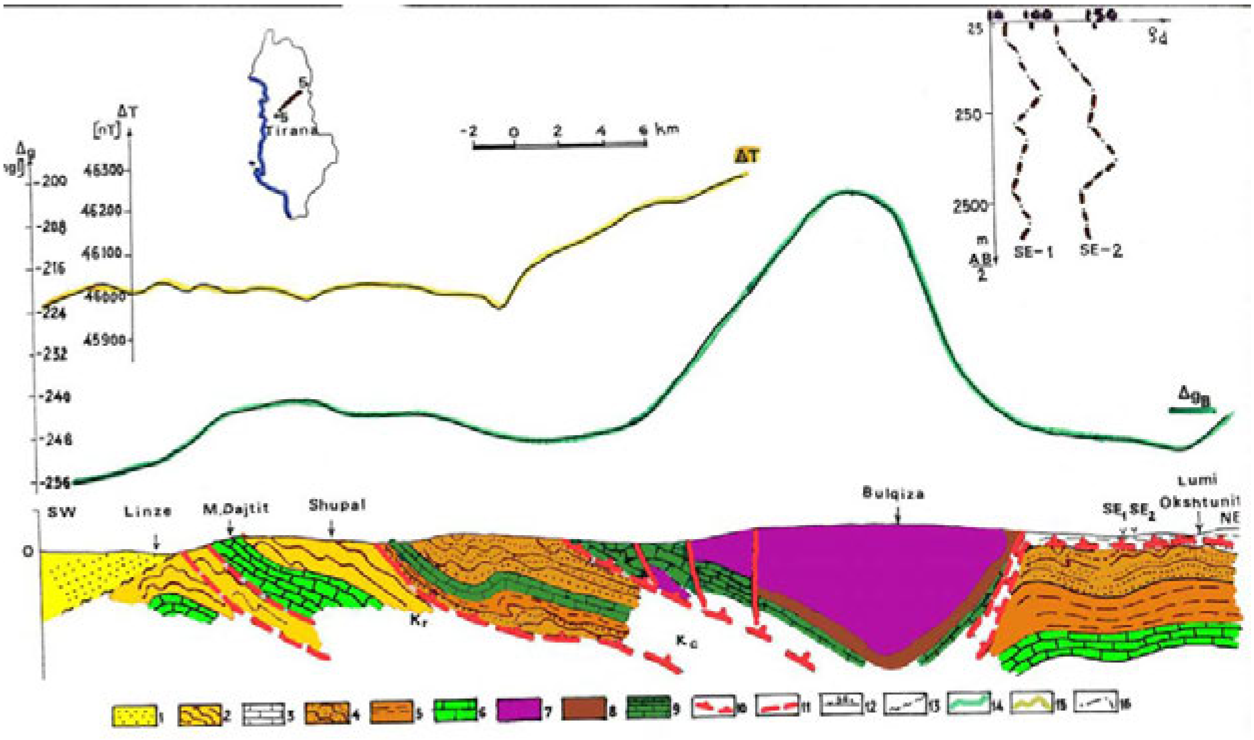


Fig. 13. Geological-geophysical profile: Tirana- Bulqizë- Shupenzë.

1- Terrigeneous Tortonian Deposts; 2- Paleogene flysch deposists; 3- Upper Cretaceous-Paleogene Limestone; 4- Titonian- lower Cretaceous flysch deposits; 5- Upper Triassic- lower Triassic limstone; 6- Radiolaritic limestone with silic radiolarities; 7- Ultrabasic rocks; 8- Effusive rocks; 9- Limestone with siliceous of midle Triassic- lower Jurassic; 10- Overthrust plave; 11- Up-rup tectonic; 12- Electrical sounding centers; 13- Unconformity surface; 14- Bouguer anomaly; 15- Magnetic anomaly; 16- Electrical sounding resistivity curve.

INTERNAL ALBANIDES

The tectonic zones of the Internal Albanides are extended in eastern part of Albania.

1. **KORABI** zone (K) continues in Pelagonian zone in Hellenides and Golia zone in Dinarides. In Korabi zone the field of Bouguer anomaly is normal and this reveals that the structures are of low orders (Fig.4). The quiet gravitational zone of Korabi in the west is in contact with the anomalous zone laid over the ophiolites of Mirdita tectonic zone. The contact between Korabi and Mirdita zone has coincides with the deep seismogene structure Ohrid-Qarishte-Qafe Murre-Kukes.

In this zone the oldest formations of Albania are present, and are represented by sanstones, schistose coglomerate and metamorphic limestone of Silurian, Devonian and Carboniferous ages, and sandstone-conglomerate and anhydrite of lower Permian-Cretaceous age. In some places there are also some volcanic and subvolcanic rocks with basic and acidic-alkaline contents. In the Korabi zone, some folds, thrust fault and cover rocks are presented.

2. **MIRDITA** zone continues with the Subpelagonian zone in Hellenides and Serbian zone in Dinarides. This zone represents a wide belt along the whole length of the country, from northeast to southeast. During the different orogenic phases, three tectonic units were formed in Mirdita zone. The lower tectonic stage is made up of ophiolites. Ophiolitic belt is characterized by intensive anomalies of the Bouguer anomaly and by a magnetic field with weak anomalies, that are very turbulent (fig. 5, 6, 7, 8, 10, 11, 12, 13).

There are three characteristics of this anomalous belt:

- Firstly, they are divided in two parts, in the north and south of Shengjergji flysch's corridor;

- Secondly, five gravity maximums, with epicenters which are set after one another in a chain according to the anomalous chain from Tropoja-Kukesi ultrabasic massif in the north-east part of Albania to the Morava massif at south-eastern area. The anomalies have maximal amplitude up to 105 mgal and are separated with strong gradients. In the northern part, the anomalous belt takes a powerful turn of 60^o-70^o in the form of northern-astern-ward direction going to the Dinarides ophiolitic belt.

- Thirdly, the biggest amplitudes of the anomalies are located over the northern part of ultrabasic massifs of the eastern belt. The southern part of the Albanides ophiolitic belt has a more limited thickness and it keeps developing southwards in Hellenides.

Falko-Tirana-Bulqiza profile interrupt transversally all the tectonic zones of Albanides (fig.8, 13). In this profile is presented clearly that the transversal profile of Bulqiza ultrabasic massif is asymmetrical. The thickest part of the massif, about 6 km.

The dip towards west of the eastern board of Bulqiza massif is proved by two vertical electrical soundings. According to these soundings, up to the depth of 2500 m, there are not observed high resistivity rocks, which can be identified with the ultramaphic rocks. (Fig. 13).

The separation of the anomalous belts of the gravity and the magnetic forces in the Shengjergji flysch's corridor, bringing evidence for the presence of Diber -Elbasan - Vlora transversal fracture, which has played a significant role in the geology of Albanides. In Shengjergji flysch corridor no

magnetic anomalies are fixed, which would testify absence of the presence of ultrabasic rocks in the east of massif's margins and under the flysch deposits (fig. 14). The Bouguer anomaly in this region is due to the presence of limestone anticline under the flysch. Vertical electrical soundings have revealed that flysch deposits have a thickness of 2000 - 2500m.

Ophiolitic belt has its biggest thickness is about 14 km in its northeastern extreme, in the ultramaphic belt of Kukes. Towards west and southeast this thickness reduced to 2 km (Fig. 10)

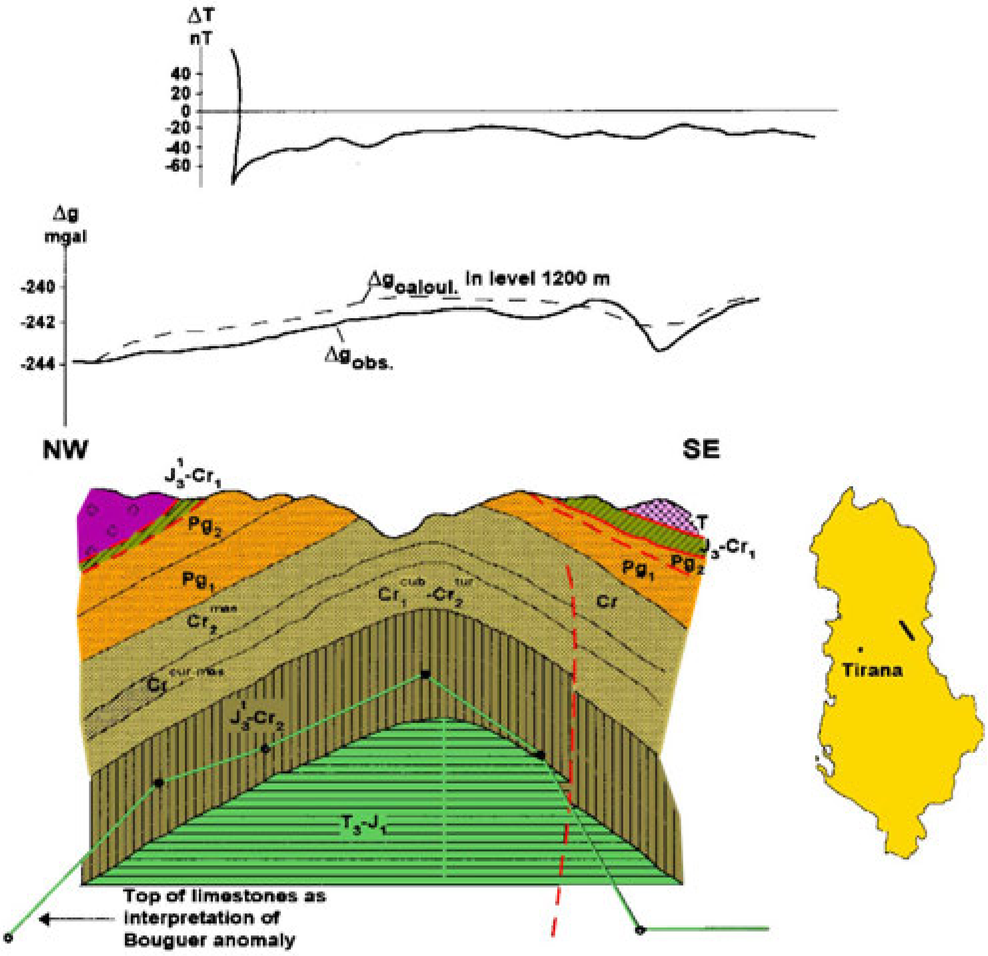


Fig. 14. Geological-geophysical profile through Peleogene and Cretaceous flysch

exposures of Okshtun window.

Abbreviations: T- Triassic; J- Jurassic, Cr- Cretaceous, Pg- Paleogene.

The northwestern sector of the ophiolitic belt is extended in the east of Shkodra town (fig. 10, 11, 12). The intensity of gravity and magnetic fields forces is reduced from seashore towards the east. The amplitude of the gravitational anomaly over the Gomsiqe ultrabasic massif is12 mGal,

which is four times smaller than in the anomalies in the eastern belt of ultramaphic massif. This proves the small thickness of western part of the ophiolitic belt. As it is seen from the graphic of the magnetic anomaly presented in the profile, shows that the ophiolites contact here dips in eastern direction with an angle about 45^{o}.
This interpretation is presented the argument about the covering character of the western contact of ophiolites belt in Mirdita zone, under which the formation of Krasta-Cukal zone is laid. This geological setting of the nappe character of the ophiolitic belt explains also the fact that, between Mirdita and Krasta-Cukali tectonic zones, the seismological studies have not proved the presence of any deep fracture.

During the tarditectonic- neotectonic stages are formed internal neogenic depressions. According to electrical soundings, carry out in Burreli fosse; result that neogene molasses have a thickness about 1500 m in the northern part of the basin (fig. 15). Under it there lies a geoelectrical layer with high resistivity which is identified with ophiolites. Under the ophiolites there is extended a layer with resistivity 100 Ohmm and thickness 500m. This layer is placed over rocks with high resistivity. This interpretation leads to the opinion those volcanoes-sedimentary formation lies over Triassic limestone. The seismic profile through this basin shows that under neogene deposits there lays a belt without seismic reflections, which is interpreted as linked with the ophiolitic formation. Under them, there lies a section with many horizontal seismic reflections, which testifies the presence of stratified section (fig.16). The seismological studies show that is observed inversion of the waves velocity dissemination in Mirdita zone (fig. 17).

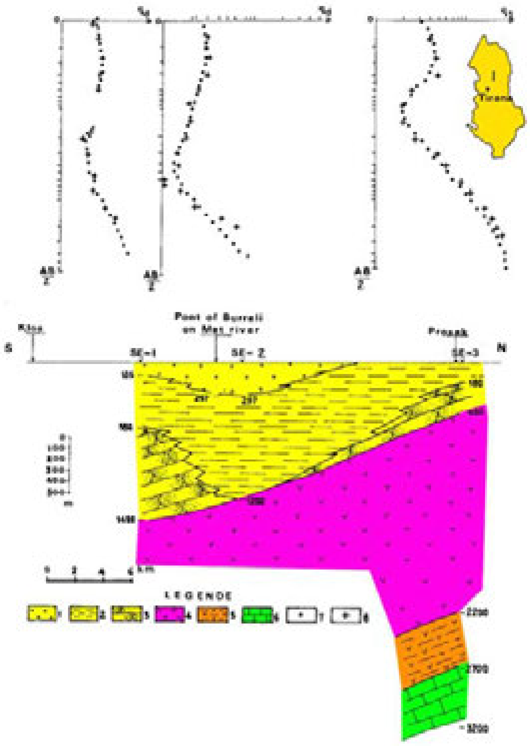


Fig. 15. Geoelectrical profile: Klos-Prosek over the Burreli Neogenic Fosse.

Quaternary gravel and conglomerate; 2- Detritic-argillaceous pack; 3- Sandstone-conglomerate; 4- Volcanic rocks; 5- Volcanogenic sedimentary pack; 6- Limestone;

All this proves that the ophiolitic belt of the Albanides is genetically unique and tectonically split into two subbelts along its length. Geophysical data are represented the arguments for overthrust character of ophiolitic belt.

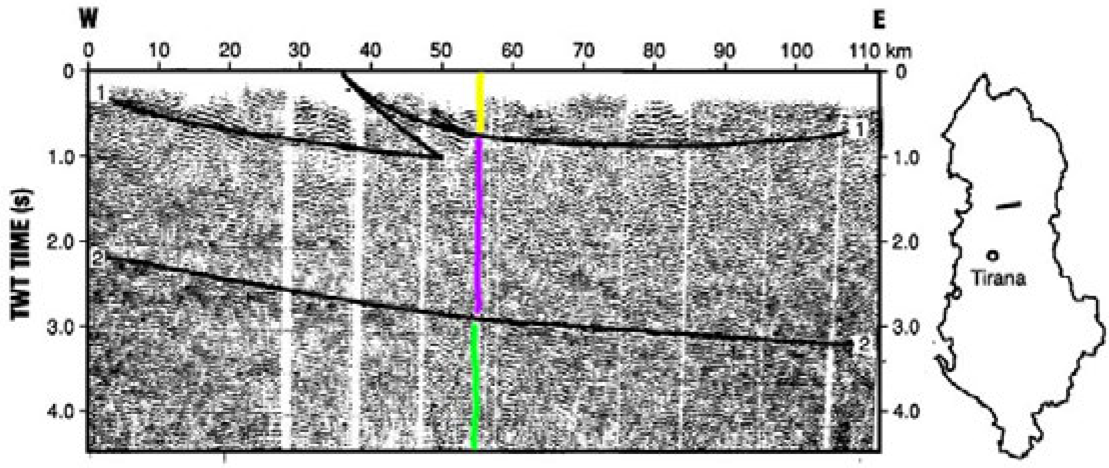


Fig. 16. Reflection seismic line in the Burreli Neogenic Fosse.

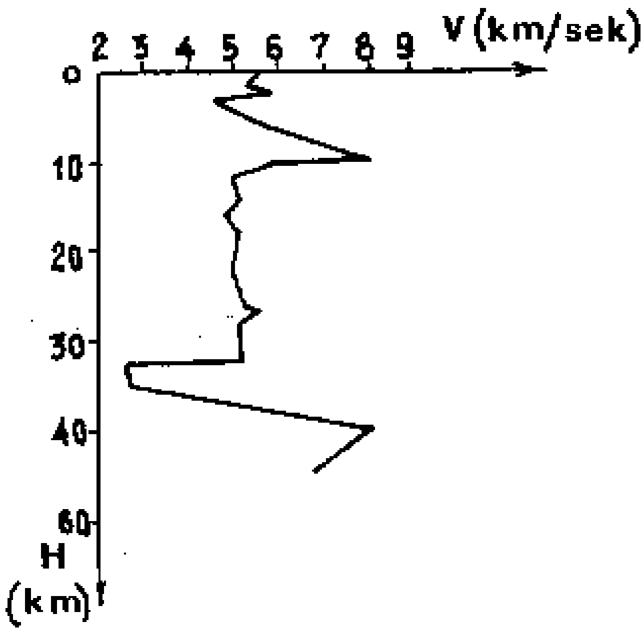


Fig. 17. Inversion of seimic P waves velocity from seismologic data (After Koçiu S., 1989).

3. **GASHI** zone (G). Beyond its border it continues into the Durmitori zone of the Dinarides. This zone includes metamorphic rocks, terrigeneous rocks, limestone, metamorphic volcanites, basic intermediate and acidic rocks.

EXTERNAL ALBANIDES

The tectonic zones of the External Albanides are extended in western part of Albania.

1. **ALPS** zone (A). Analogue with Parnas zone in Hellenides and it continues with High Karst in Dinarides. In this zone the sandstone and the conglomerates of Permian are the oldest rocks. In general, Alps represents limestone monoclines, combined with smaller anticlines. A regional gravity minimum is extended in the Alps zone. Local gravity maximums are extended over the carbonatic structures (Fig. 18).

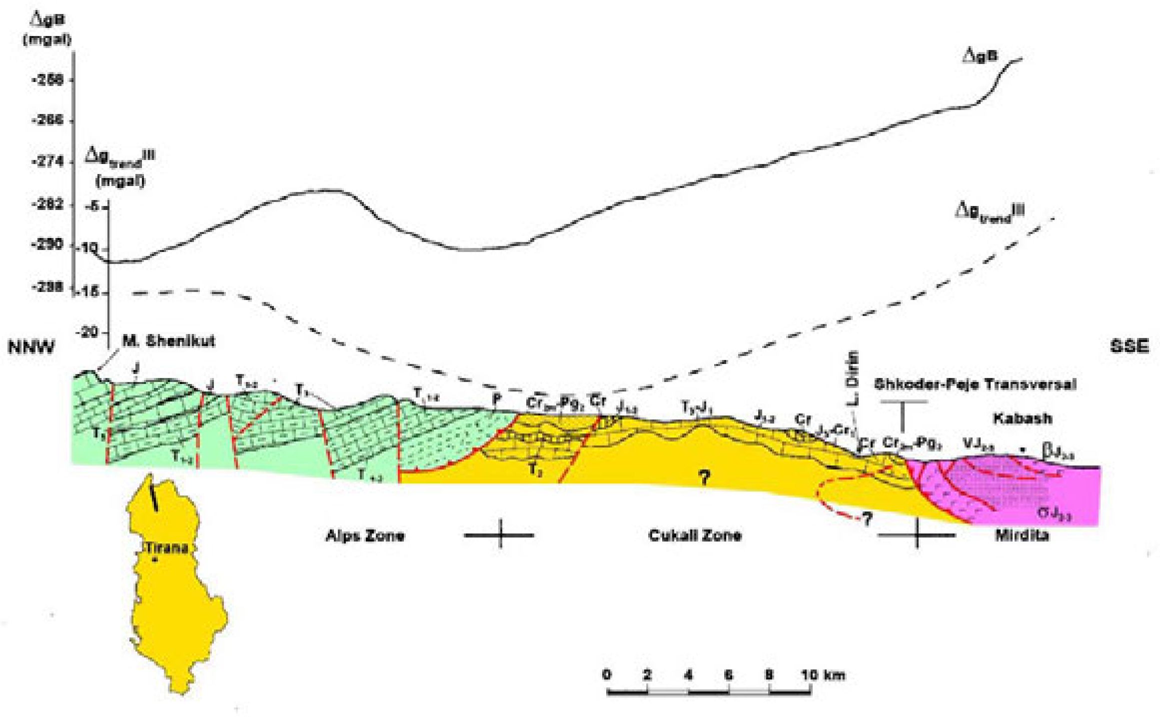


Fig. 18. Geological-geophysical profile: Alps-Cukali-Mirdita zones, over the

Shkodër- Pejë Transversal.

2.KRASTA-CUKALI zone (K - C) continues in Pindos zone in Hellenides and Budva zone of the Dinarides. Krasta subzone lies like a narrow belt from Shkodra City in northwest region of Albania to Leskovik City at southeast region of Albania. This is an intermediately zone between the Internal and External Albanides. The longitudinal profile passes through the northwestern margin of ophiolitic belt, through Cukali and reaches to the Albanian Alps, interrupting Shkoder–Peje transversal (fig.18). Residual Bouguer anomaly has a monotonous increase in the southeastern part of this profile. This increase may be caused by:

Firstly, the increase of the thickness of the limestone formations of Triassic up to Cretaceous towards the border of Cukali and Mirdita zones,

Secondly the probability of existence in this zone of ophiolitic rocks covered by the formations of Cukali.

Thirdly the presence of Paleozoic formations with big density near the earth surface in this sector.

3. **KRUJA** zone (K) continues with Dalmate zone in Dinarides and in the south by Gavrova zone of the Hellenides. According to the seismic data in the central regions of Kruja zone, are noticed reflection in the seismic sections in 2.3-2.5 seconds which is partially parallel with the above reflections, identified as limestone roof of the structures of Kruja zone (fig.19). Basing on the nature of reflections and the data of the neighboring countries they may be connected with the roof of Jurassic-Cretaceous salts. Secondly, a deep overthrust regional disjunctive tectonic may pass. In this case, terrigene (flysch) section would lay under 2-2 reflection and going deeper we would expect new carbonate structures with perspectives for oil and gas discovery.

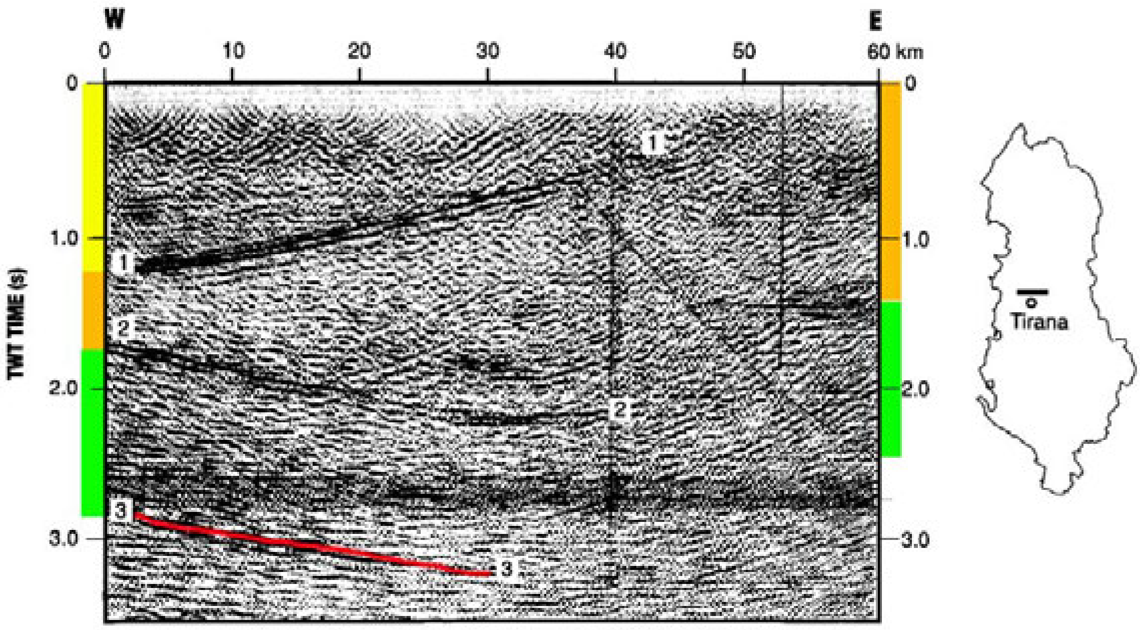


Fig. 21. Reflection seismic line in the Tirana Neogenic Depression.

4. **IONIAN** zone (Io) continues with the same name beyond borders in Greece. The Ionian zone occupies the southwestern part of Albania with SE-NW axis. This is the biggest zone of External Albanides and has been developed as a deep pelagic through since upper Triassic. The Permian-Triassic evaporites are the oldest rocks of this zone. Over this formation lies a thick deposits formed by upper Triassic- lower Jurassic dolomitic limestone and Jurassic-Cretaceous-Paleogene pelagic cherty limestone. Limestone are covered by Paleogenic flysch, Aquitanian flyschoidal formation, thin section of Burdigalian-Helvetian and partially of Serravalian-Tortonian, which mainly fill the synclinal belts. Burdigalian deposits are placed in angle discordance over anticline belts. This has brought about two- stage structure.

During the Liassing rifting affected External Albanides including Ionian zone and in this last were formed three tectonic blocks that represent the structural belts:

a. Berati anticline belt, in the eastern margin of the zone

b. Kurveleshi anticline belt, in the central part of the zone. According to the reflection seismic results have been compilated spatially map the carbonates.

c. Çika anticline belt, which represents the western edge of the Ionian zone.

By the geological-geophysical data many anticline structures are delimited in the carbonate deposits inside these tectonic belts. Structures are fractured by longitudinal tectonic faults in western structure flanks.

The Berati anticline belt

The seismic acquisitions on this belt are performed in different times and by different techniques. The seismic situation in the time sections is very complicated and for the top of limestone, only some separated reflections in certain lines are recorded, especially in its central and western part, probably because limestone in this zone are deep and faulted. According to the seismic data, limestone in the central part are markedly broken.

This conclusion is well supported by the deep wells, drilled in Sqepur- Bistrovica area.

Kurveleshi anticline belt

All our conclusions are refereed mainly to carbonate formation, because those for the flysch section over the limestone, based on numerous facts, have produced wrong conclusions. The Kurveleshi belt is constructed by structures of various forms and dimensions, associated with developed tectonics up to thrusting of 5-10 km horizontal displacement, in the west of its structures as well as in eastern flanks is associated with diapiric eruptions. In regional seismic line II-II, which crosses the Ionian zone, from west to east, we can see clearly the perspective oil and gas-bearing structures.

Çika anticline belt

Çika anticline belt is constructed mainly by prolonged structures, with considerable dimensions, and associated with evaporate outcrops as in Xara, Fterra, Çika etc. Seismic works in this belt, date back to the start of exploration in Albania and still continue today. Earlier techniques

for field acquisition have been those of one fold coverage, which continuously are improved, switching in the last years to multiple fold coverage.

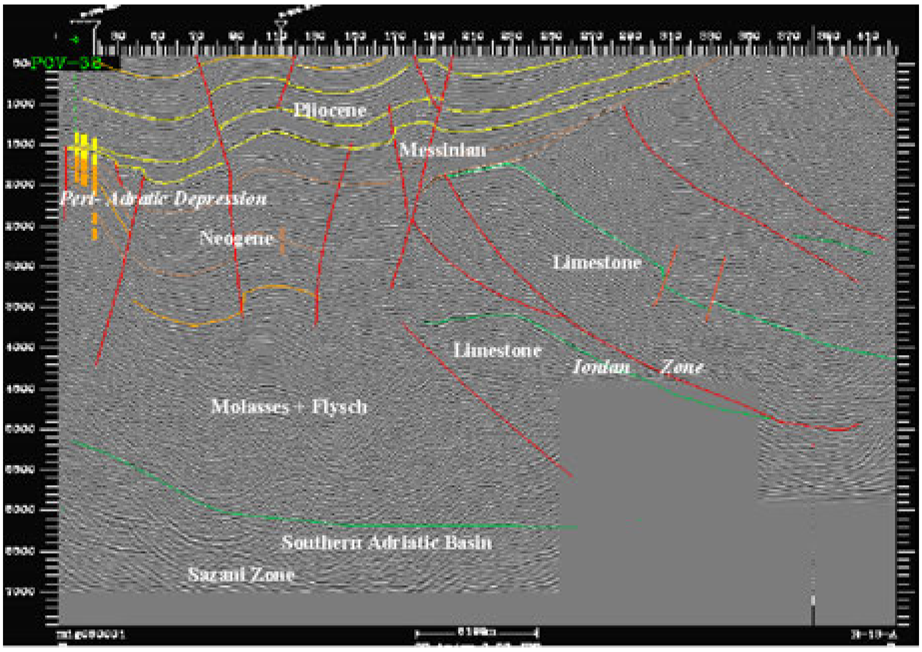


Fig. 20. Regional reflection seismic line in Ionian and Peri-Adriatic Depression.

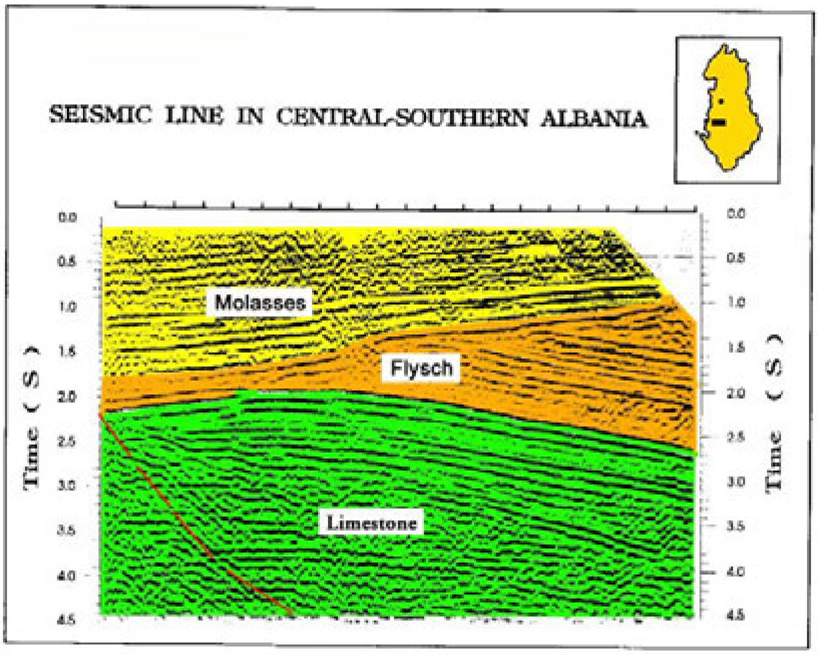


Fig. 20-a. Reflection seismic line in Ionian and Peri-Adriatic Depression.

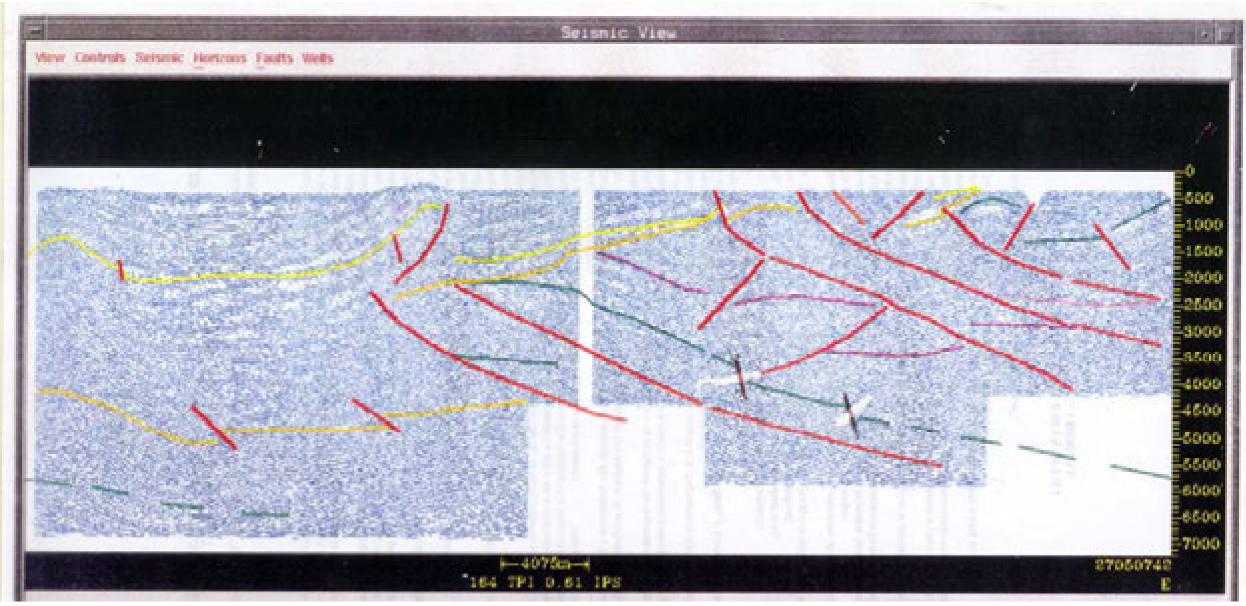


Fig. 20-b. Reflection seismic line in Ionian and Peri-Adriatic Depression (After AKH).

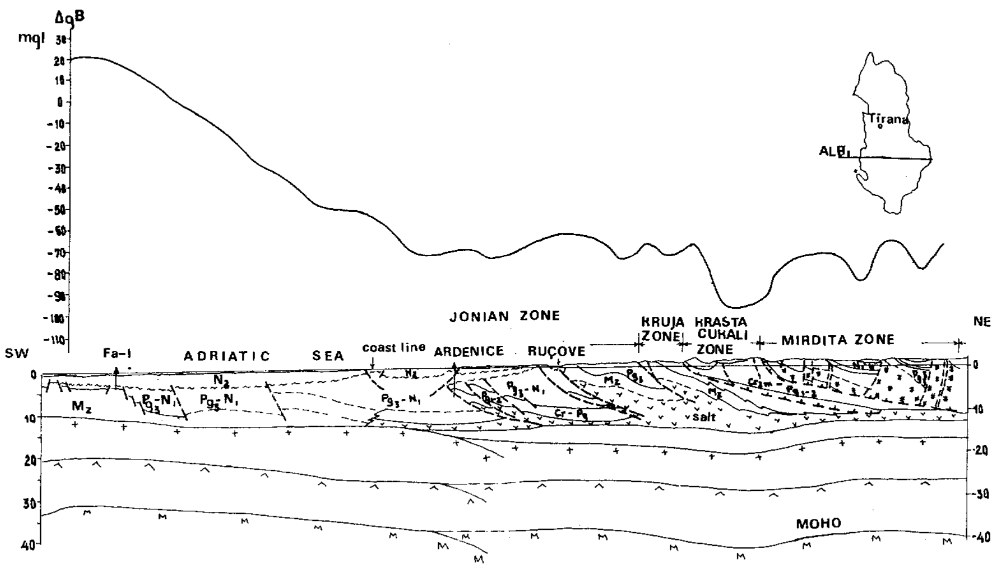


Fig. 21. Geological-geophysical profile Albanid-1: Falco Adriatic Sea- Seman-

Kuçovë- Bilisht (The gravity data for the Adriatic Sea after Richetti, 1980).

Legend as in the fig. 8.

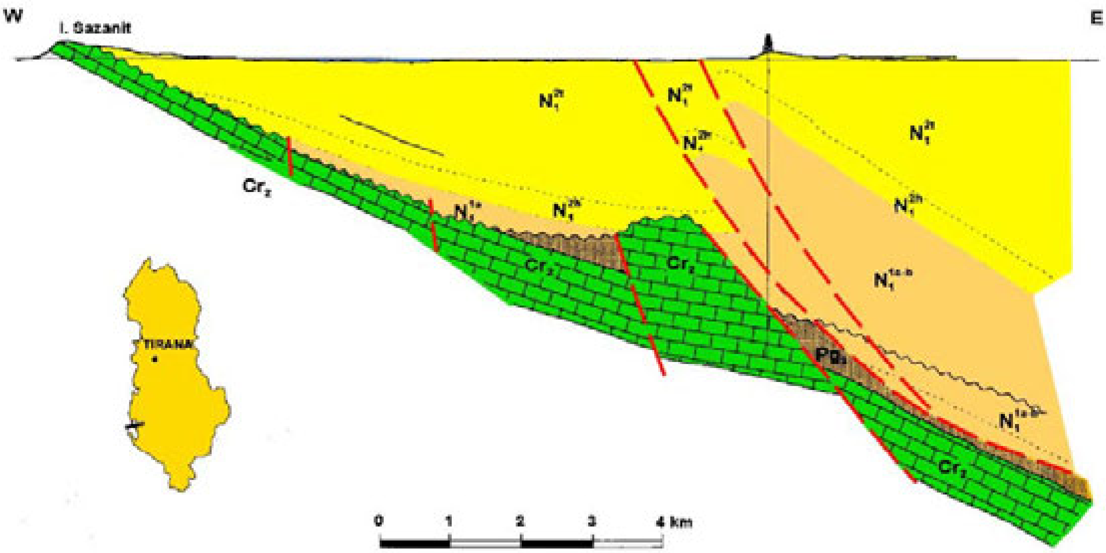


Fig. 22- Geological profile of Sazani-Zvërnec in Vlora district.

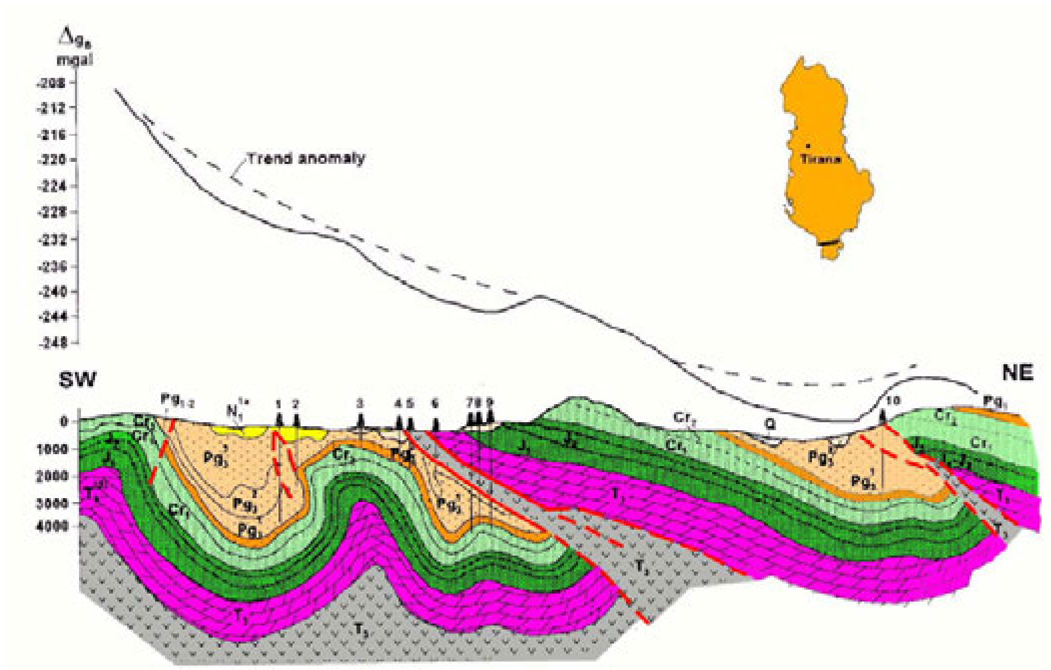


Fig. 23. Geological-geophysical profile: Saranda-Gjirokastra region.

1. Quaternary; 2- Pliocene; 3- Helevtian; 4- Burdigalian; 5- Aquitanian; 6- Upper Oligocene; 7- Midle Oligocene; 8- Lower Oligocene; 9- Lower Oligocene of suite Tomorri; 10- Eocene; 11- Paleocene; 12- Upper Cretaceous; 13- Lower Cretaceous; 14- Lower Jurassic; 15-Midle Jurassic; 16- Lower Jurassic; 17- Dolomites of the Upper triasic; 18- Upper Triassic with evaporites; 19- Paleozoic (substratum of Ionian zone); 20- Verified paleological boundary; 21- Supposed geological boundary; 22- Verified lithological boundary; 23- Supposed lithological boundary; 24- Transgresive boundary; 25- Lithological marker; 26 Verified fault;27- Supposed fault; 28- Seismic reflector; 29- Normal attitude element; 30- Reversed attitude element; 31- Intersection of the seismic lines; 32- Trend of the Bouguer Anomaly; 33- Bouguer anomaly; 34- Depth wells.

Two main tectonic styles are distinguished in the Ionian zone: Duplex tectonic and imbricate tectonic styles. The back thrust faults have been caused by retro tectonic phenomena. The geodynamics of the Ionian zone is related with the evolution of the transversal tectonic faults. These faults have separated the Ionian basin in several blocks, since rifting time of lower and middle Jurassic. The periodical tectonic movement of the transversal faults has played an important role this over thrusting phenomenon, too.

In the regional reflection seismic lines through Ionian zone is clearly seen that during the structuring process of the Ionian zone, from upper Oligocene to Langhian, the underlying of southern Adriatic basin limestone and Sazani Zone has taken place (Fig. 22, 23).

5. **SAZANI** zone is the continuation of Apulian platform. A thick Cretaceous- Eocene limestone and dolomite section builds this). Marly deposits of Burdigalian are place trangressively over carbonatic formation (fig.22).

The interpretation of the recent geological geophysical data represents a new structural model and the tectonic styles of the External Albanides. Tectonic zones of the External Albanides are in compression tectonic regimen since upper Jurassic-Cretaceous periods. Only in western part, Apulian zone and South Adriatic basin, are in continues extension tectonic regimen. Over thrusting style of the south-eastern part of the External Albanides, with a great southwestward overthrust of the anticline chains, the presence of the old transversal faults at the present are well known. The lubrication substratum is represented by evaporites during the over thrusting movement. The regional neotectonic phenomena are also the back thrusting tectonic in the Ionian and Sazani zones. The formed structural-tectonic models are represented the results of interference of two main effects, that of southwestward over thrusting and that of secondary and newly northwestwards over thrusting.

6**. PERI-ADRIATIC DEPRESSION**

Overlying Peri-Adriatic Depression covers the Ionian, Sazani and partly Kruja tectonic zones. This is a fore depression filled with middle Miocene and Pliocene molasses, which are mainly covered by Quaternary deposits (fig.8, 20, 21, 24). Tortonian- Messinian- Pliocene molasses consist of a considerable number of sandy-clay mega-sequences. From south-east to north-west, the thickness of the molasses increases, reaching 5000 m. Sandstone-clay deposits of Serravalian and Tortonian are placed trangressively over the oldest ones, up to the limestone creating a two-stages structure (Fig. 20, 24).

During the molasses cycle, the structure and structural chains of the Ionian, Kruja and Sazani zones have increased the thrusting and back thrusting degree, as a result of a powerful tectonics development. This phenomenon often led to the formation of tectonic blocks, within the carbonatic section, of imbrications nature and to the partial and complete reaching of the expected anticline structures from the evaporites and the adjacent eastern structures.

The Albanian sedimentary basin continues even in Adriatic shelf with terrigene and carbonatic formations. In the different profiles (fig.8, 14) it is noticed that there exist some local Bouguer and magnetic anomalies in Adriatic shelf (Richetti, 1980). Some researchers have reached the conclusion that the Apulian platform is tectonically quiet. The local gravity maximums coincide with minimums of the magnetic field: this is interpreted as due to the elevation of the top of carbonatic formation.

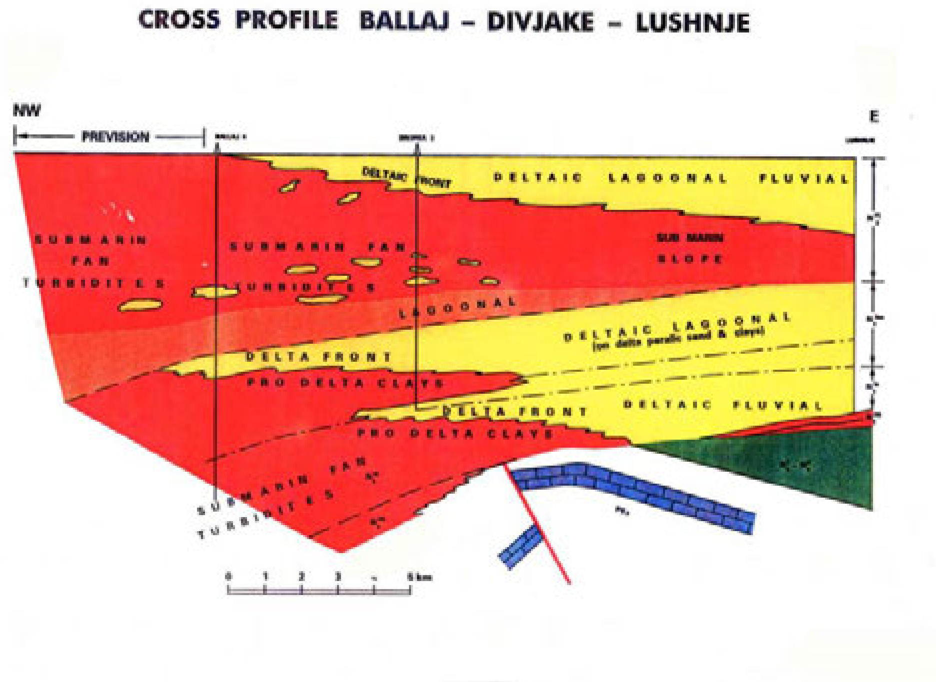


Fig. 24. Reflection seismic line: Divjaka brachianticline in Peri-Adriatic Depression.

(After Dyrmishi C).

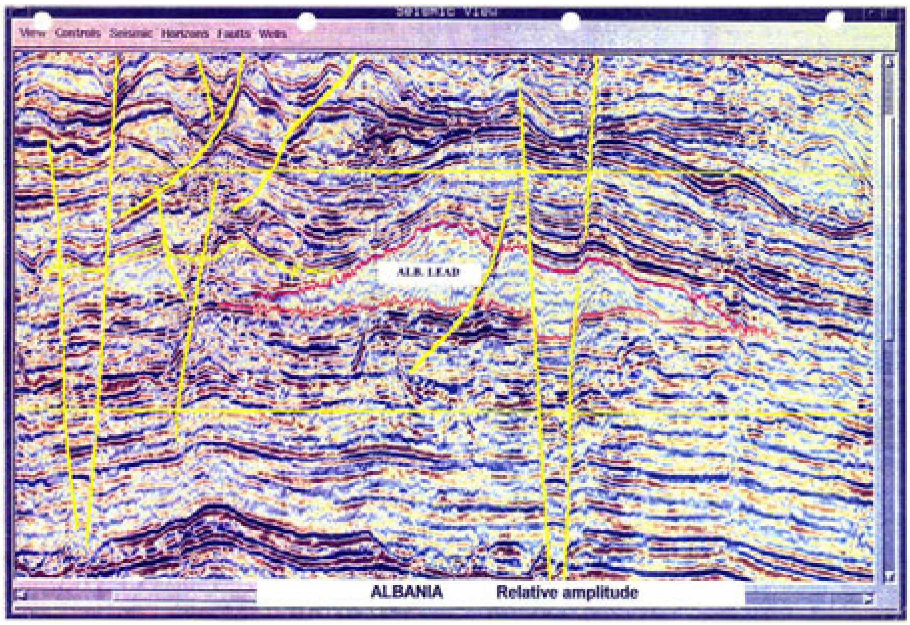


Fig. 24-b. Seismic line in Peri-Adriatic Depression (After AKH).

PALEOMAGNETIC OUTLOOK ON DYNAMIC EVOLUTION OF ALBANIDES

Dynamic evolution of the Albanides has its reflection in paleomagnetic data, collected from the paleomagnetic studies in Albania, which were performed during 90 years (Frasheri et Bushati 1995,

Frasheri et al. 1995, Kane et al. 1999, Kissel et al. 1992, 1994, 1995, Mauritsch et al. 1991, 1994, Mauritsch 2000).

Paleomagnetic studies shows that Ionic and Kruja tectonic zones have support a joint clockwise rotation, with an angle 45-50^o during and after Eocene-Oligocene period. This rotation has been realized through two phases, by 25^o every phase in the middle Miocene up to Plio-Pleistocen. Ionic and Kruja zones don't have any different rotation between each other. Vlora- Elbasan- Diber don't divided zones with different rotations of the central and northern part of the Albania. Consequently, maybe observed practically continuously evolution of the External Albanides zones from upper Eocene up to present (Fig. 25).

In the upper Miocene section in Peri-Adriatic Depression has been observed that between Oligocene and upper Miocene, the External Albanides zones have been subdued a clockwise rotation of 10-15^o. In the clay of Pliocene section at Central Albania was observed 10o rotation, which have been supported External Albanides zones during the upper Miocene and lower-middle Pliocene. Has been evidenced also a clockwise rotation of the External Albanides and Internal Albanides younger that Tortonian, in the relation with general apparent polar displacement path from the Africa and Eurasia (Fig.26, 27). Eocene limestone anticlines of the Renz and Kakariq area, which are located in the Shkoder-Peje transversal zone, have a rotation about 31^o. Consequently, these two anticlines have a declination with 18o smaller than the declination of the Eocene limestone in the Central Albania. These two anticlines maybe have superposition of two rotations with inverse sense: clockwise rotation of 50o, which has been subdued all External Albanides structures and local counterclockwise rotation by 25o, which has rotated only these two anticlines that have a Dinaride strike.

Limestone samples from Albanian Alps at Selca area, in the north of Shkoder-Peje transversal, shows a counterclockwise rotation for 20o in relation with present north, the same value as in southern Dinaride's structures.
The analogue counterclockwise rotation as in Selca area, have also Jurassic limestone at southern Shkodra lakeshore. This fact shows that both these sections appertain to the same tectonic zone, in northern of Shkoder-Peje transversal area. This lineament has great tectonic influence over Cukali subzone, where have observed changes of the sense of from counterclockwise to clockwise rotation in very short distances. In the northwestern edge of the Mirdita zone, at the Komani area of ophiolitic belt, have been observed declinations, which show the clockwise rotation of the effusive rocks and sedimentary ones.

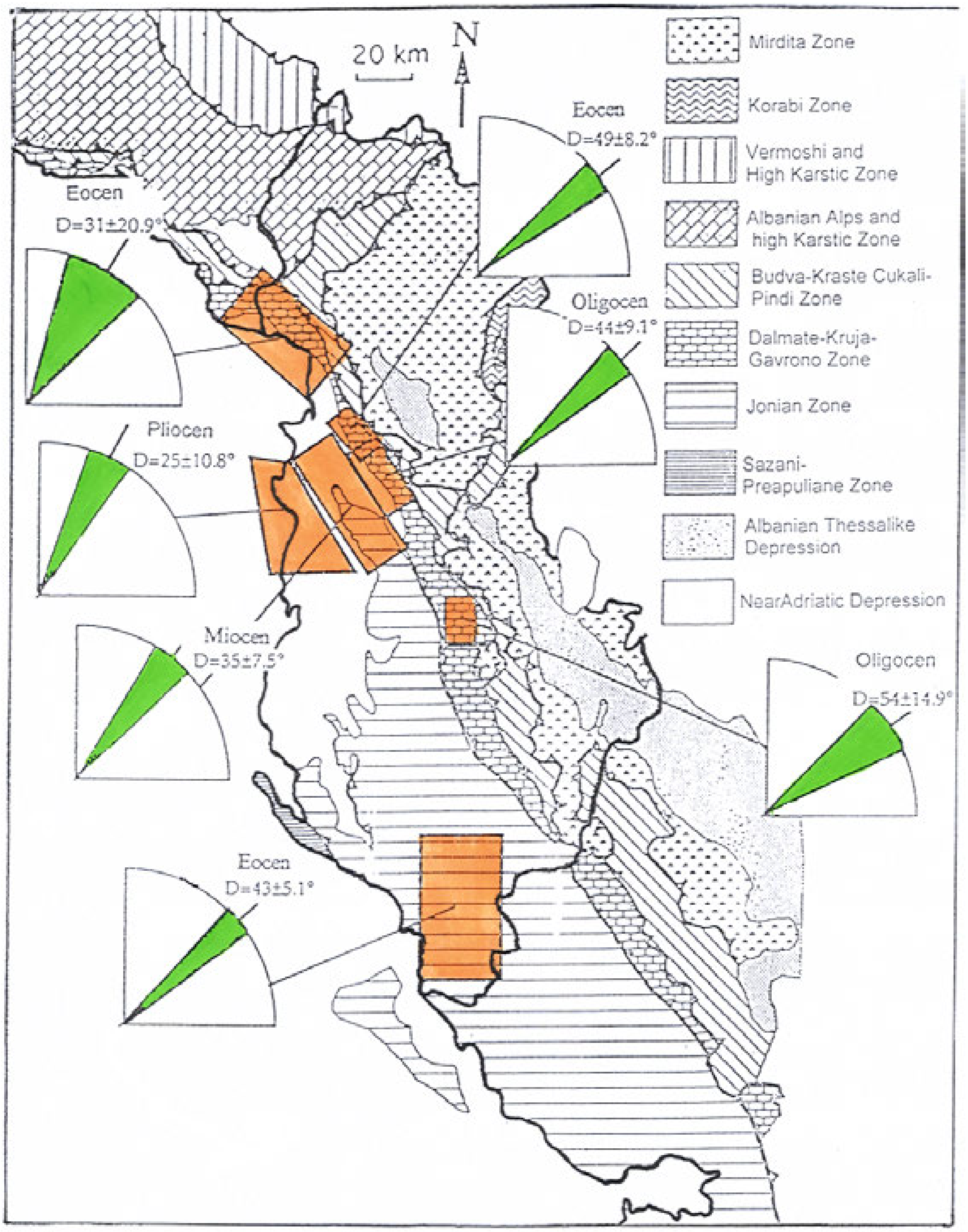


Fig. 25. Paleomagnetic Declinations Map of the External Albanides.

(After Kisel C. et al. 1994).

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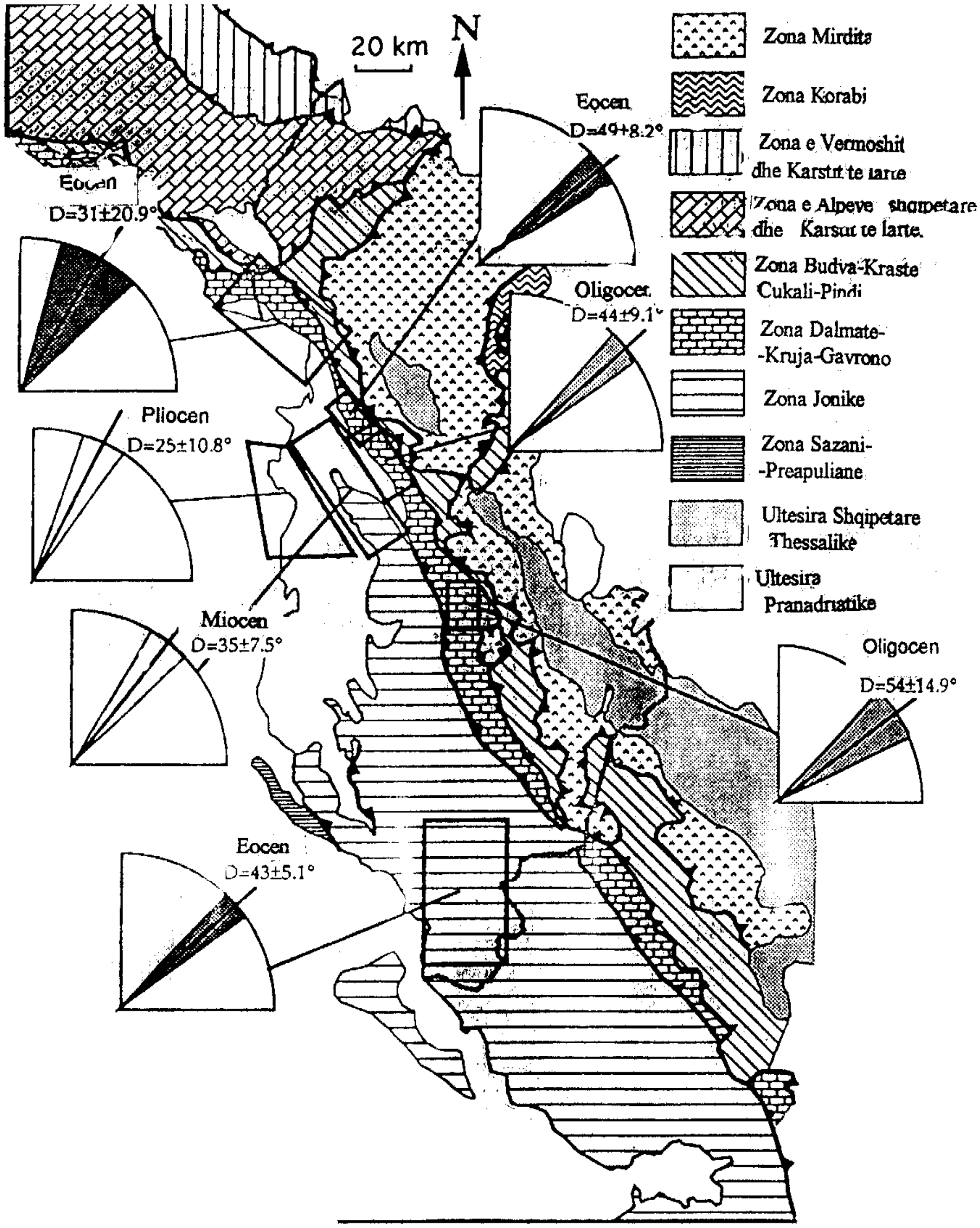

Fig. 26. Regional Paleomagnetic Declinations around Adriatic Sea and expected paleomagnetic declination for Africa during the Eocene-middle Pliocene period, (After Speranza F. 1995).

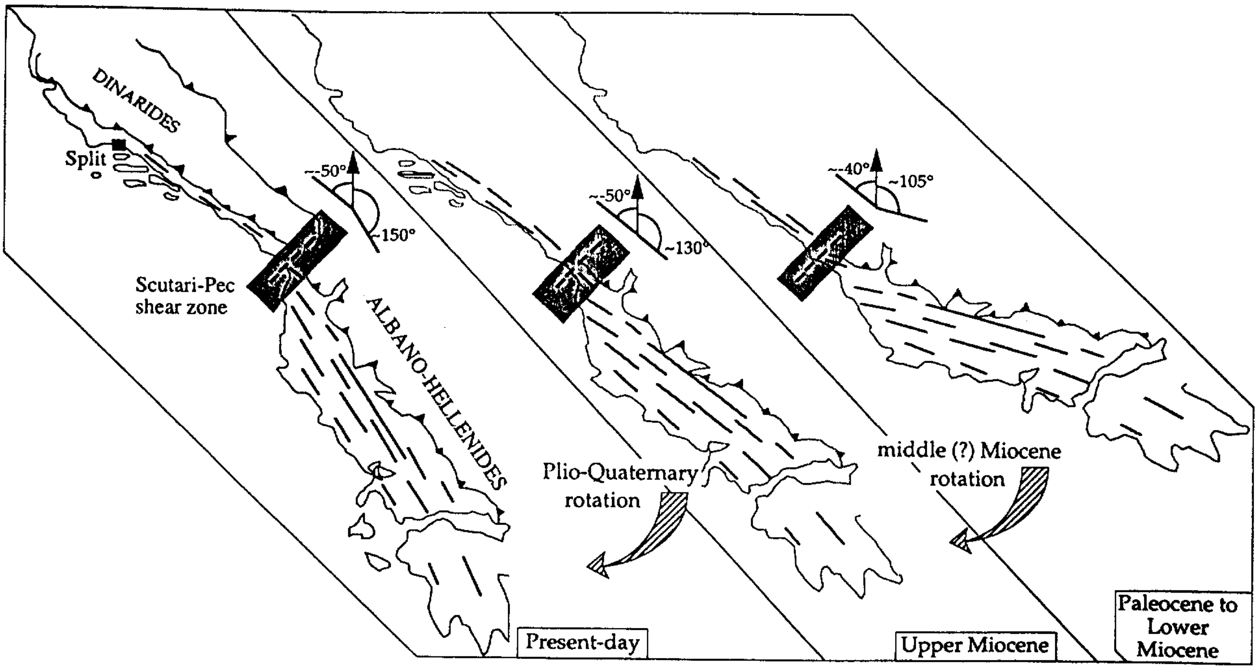

Fig. 27. Schematic evolution of the orientation of Albanides-Hellenides and

Dinaride structures during the Cenozoic era, (After Speranza F. 1995).

Shkoder-Peje lineament forms the transition between two zones: of counterclockwise rotation of Albanian Alps and Dinarides to its north and clockwise rotation of the Albanides and Hellenides to its south.

Magneto-biostratigraphic studies which have been performed at Kçira area in Mirdita zone, shows that in the Spathian-Anisian section have observed alternation of normal and inverse magnetization. Kçira Pole presents affinity with Western Gondwana after restoration for the Neogene (Muttoni G. et al, 1996).

Results of paleomagnetic investigation of the samples from ophiolitic belt in Internal Albanides, from Qafëzezi in south of Korça district to the Kalimashi area in Kukësi ultrabasic massif in the north-east of Albania, shows the same declination as the Hellenides ophiolitic belt.

CONCLUSIONS

1. Albanides are presented the assemblage of geologic structures, which are extended in the Albanian territory. They are placed between Dinarides in North and Hellenides in South. The geophysical and geological studies have proved the presence of some tectonic zones, situated in two big paleogeographic zones, in the Internal Albanides and in the External Albanides.

2. Earth Crust of the Albanides has a block construction. The Earth crust in Albanides is interrupted by a system of longitudinal fractures in NW-SE direction and transversal fracture that touches the mantel. Some of them separate even the tectonic zones. With deep fractures are linked geothermal energy of the Albanides.

3. The Mirdita ophiolitic complex causes an obvious gravity anomaly chain and a turbulent magnetic field, relatively of low intensity. These data show about the allochthone character of ophiolitic belt. The interpretation of the gravity data reveals a big thickness of the ophiolitic belt of 6-14 km on the eastern belt of the ultrabasic massifs, while it is decreased up to 2 km on the West.

4. Tectonic zones of the External Albanides are in compression tectonic regimen since upper Jurassic-Cretaceous periods. Western part, Apulian zone and South Adriatic basin is in continues extension tectonic regimen.

5. The geophysical data show that the orogene front of Albanides is emplaced in Adriatic Sea. The Ionian and Sazani zones continue for a certain of distance in the Adriatic Sea Shelf. Both these zones are extended over the Apulian platform.

6. The relations between the Internal and the External Albanides have a southwestward nappe character.

7. Paleomagnetic studies have demonstrated that assemblage of the Albanides margin has supported a clockwise rotation with amplitude about 45o, after upper Oligocene. This rotation has been realized by two phases, analogue with the phases, which are observed in the western margin of the Hellenides. Shkoder-Peje transversal is represented a transition zone between the clockwise rotation of the Albanides and Hellenides and counterclockwise of the Dinarides. Horizontal displacement is about 173 km in southern Albania, for the rotation pole located at Shkoder-Peje transversal.

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LIST OF CAPTIONS

Fig. 1. Schematic Map of African Plate Subduction under the Euroasiatic one (After Ricou, El. 1986)

2- Euro-Asiatic Continent; 2- African continent; 3- Kishir block; 4- Presents Oceanic Basins; 5- Boundaries of Mesozoic Oceans; 6- Boundaries of Mesozoic Ocean and the Main Ophiolitic Nappes; 7- Troughs of present and past subduction.

Fig. 2. Schematic Tectonic Map of Albania.

Tectonic zones: 1- Sazani; 2- Ionian; 3- Kruja; 4- Krasta-Cukali; 5- Albanian Alps; 6- Gashi; 7- Korrabi- 8- Mirdita; 9- Peri-Adriatic Depression; 10- Albanian-Thessalinian depression; 11- Main overthrust; 12- Main fractures.

Fig. 3. Geologic structure of Earth's Crust and Upper mantle based on seismological studies (data taken from Koçiu S. 1989).

The numbers given in legen show the velocity of the seismic waves, in km/s).

2- Sedimentary Crust; 2- Consolidated crust; 3- Granitic Crust; 4- Basalt Crust; 5- Upper mantle; 6- Asthenospehere; 7- BK Crystal Basement; 8- Moho Discontinuity.

Fig. 4. Bouguer Gravity Map of Albania (After V. Veizaj 1994).

Fig. 5. The Complex Tectonic Map and map of the trend of 3rd degree of Bouguer Anomaly in the Albanides.

2- Peri-Adriatic Depression; 2- Ionian Zone; 3- Kruja zonw; 4- Krasta-Cukali zone; 5- Sazani zone; 6- Mirdita zone; 7- Korabi zone; 8- Gashi zone; 9- Albanian Alps zone; 10- Vermoshi zone; 11- trend of 3rd degree of Bouguer Anomaly; 12- Boundary between shelf and continental slope; 13- The axes of the up-left and down-left of the Mante; 14- Boundary of the Peri-Adriatic Depression with angular discordance; 15- Normal fault; 16- Pressure; 17- Limit of deformed envelopment during the neotectonic period; 18- Overthrust; 19- Flexure; 20- Flexure and faults based on geophysical data; 21- Inactive overthrust; 22- Compression (a) and (b) extension zones; 23- Deep faults.

Fig. 6. The Complex Tectonic Map and axes of the Bouguer anomaly in the Albaniedes and in continental plate of the Adriatic Sea.

2- Peri-Adriatic Depression; 2- Ionian Zone; 3- Kruja zonw; 4- Krasta-Cukali zone; 5- Sazani zone; 6- Mirdita zone; 7- Korabi zone; 8- Gashi zone; 9- Albanian Alps zone; 10-

Vermoshi zone; 11- The axes of the Bouguer Residual Anomalies, positive (a) and negative (b); 12- Isoanomals of the Bouguer Anomaly in the Adriatic and Ionian Sea (after Morelli C et al. 1969); 13- The axes of the up-left and down-left of the Mante; 14- Boundary of the Peri-Adriatic Depression with angular discordance; 15- Normal fault; 16- Pressure; 17- Limit of deformed envelopment during the neotectonic period; 18- Overthrust; 19- Flexure; 20- Flexure and faults based on geophysical data; 21- Inactive overthrust; 22- Compression (a) and (b) extension zones; 23- Seismogene deep up-rupt; 24- Isobaths of the water depth, in meters.

Fig. 7. The Complex Tectonic Map and Total Magnetic anomalies in the Albanides and in

Adriatic Sea continental plate.

2- Peri-Adriatic Depression; 2- Ionian Zone; 3- Kruja zone; 4- Krasta-Cukali zone; 5- Sazani zone; 6- Mirdita zone; 7- Korabi zone; 8- Gashi zone; 9- Albanian Alps zone; 10- Vermoshi zone; 11- Isoanomals of residual total magnetic anomalies; 12- Boundary between shelf and continental slope; 13- Normal faults; 14- Boundary of the Peri-Adriatic Depression with angular discordance; 15- Pressure; 16- Limit of deformed envelopment during the neotectonic period; 17- Overthrust; 18- Flexure; 19- Flexure and disjunctions based on geophysical data; 21- Inactive overthrust; 22- Depth seismogenic up-rupt.

Fig. 8. Geological-geophysical profile Albanid-2: Falco Adriatic Sea- Durres-Tirana- Peshkopi

(The gravity data for the Adriatic Sea after Richetti, 1980).

3. Pliocene Sustratum; 2- Substratum of Serravalian Molasses; 3- Paleogenic flysch (Pg_3) and molasses over the limestone; 4- Flysch of the Mastrichtian ($Cr^m{}_1$), Lower and Middle Paleogene (Pg_{1-2}); Old flysch of Jurassic (J) and middle Cretaceous (Cr_2); 6- Carbonatic facies divided by the tectonic zones; 7- Ultrabasic rocks; 8- Disjunctive tectonic; 9- Depth up-rupt; 10- Top of chrystal basement; 11- The basal of the Earth Crust; 12- Moho Discontinuity' 13- Focus nodal plan of the earthquakes in the Kavaja region, western Albania; 14- Seismic reflection; 15- Deep well.

$G_{B,t}$- Trend of 2nd degree of Bouguer anomaly,

$G_{B,t}$- Residual Bouguer anomaly,

T_t - Trend of the 2nd degree of total magnetic anomaly,

T_r - Residual of the 2nd degree of total magnetic anomaly,

T_o - Observed magentic anomaly.

Fig. 9. Heat Flow Density Map of Albania.

Fig. 10. Geological-geophysical Shkodër-Kukës profile.

2- Effusive rocks; 2- Ultrabasic rocks; 3- Gabbro; 4- Sedimentary formation; 5- Disjunctive tectonic.

Fig. 11. Geological- geophysical profile: Adriatic Sea- Vrith

Fig. 12. Geological-geophysical profile: Shëngjin- Vrith.

Fig. 13. Geological-geophysical profile: Tirana- Bulqizë- Shupenzë.

2- Terrigeneous Tortonian Deposts; 2- Paleogene flysch deposists; 3- Upper Cretaceous-Paleogene Limestone; 4- Titonian- lower Cretaceous flysch deposits; 5- Upper Triassic- lower Triassic limstone; 6- Radiolaritic limestone with silic radiolarities; 7- Ultrabasic rocks; 8- Effusive rocks; 9- Limestone with siliceous of midle Triassic- lower Jurassic; 10- Overthrust plave; 11- Up-rup tectonic; 12- Electrical sounding centers; 13- Unconformity surface; 14- Bouguer anomaly; 15- Magnetic anomaly; 16- Electrical sounding resistivity curve.

Fig. 14. Geological-geophysical profile through Peleogene and Cretaceous flysch exposures of Okshtun window.

Abbreviations: T- Triassic; J- Jurassic, Cr- Cretaceous, Pg- Paleogene.

Fig. 15. Geoelectrical profile: Klos-Prosek over the Burreli Neogenic Fosse.

1- Quaternary gravel and conglomerate; 2- Detritic-argillaceous pack; 3- Sandstone-conglomerate; 4- Volcanic rocks; 5- Volcanogenic sedimentary pack; 6- Limestone; 7- Synthetic vertical electrical sounding curve; 8- Observed vertical electrical sounding curve.

Fig. 16. Reflection seismic line in the Burreli Neogenic Fosse.

Fig. 17. Inversion of seimic P waves velocity from seismologic data (After Koçiu S., 1989).

Fig. 18.Geological-geophysical profile: Alps-Cukali-Mirdita zones, over the Shkodër- Pejë Transversal.

Fig. 19. Reflection seismic line in the Tiran Neogenic Depression.

Fig. 20. Regional reflection seismic line in Ionian and Peri-Adriatic Depression.

Fig. 20-a. Reflection seismic line in Ionian and Peri-Adriatic Depression.

Fig. 20-b. Reflection seismic line in Ionian and Peri-Adriatic Depression.

Fig. 21. Geological-geophysical profile Albanid-1: Falco Adriatic Sea- Seman-Kuçovë- Bilisht

(The gravity data for the Adriatic Sea after Richetti, 1980). Legend as in the fig. 8.

Fig. 22- Geological profile of Sazani-Zvërnec in Vlora district.

Fig. 23. Geological-geophysical profile: Saranda-Gjirokastra region.

1- Quaternary; 2- Pliocene; 3- Helevtian; 4- Burdigalian; 5- Aquitanian; 6- Upper Oligocene; 7- Midle Oligocene; 8- Lower Oligocene; 9- Lower Oligocene of suite Tomorri; 10- Eocene; 11- Paleocene; 12- Upper Cretaceous; 13- Lower Cretaceous; 14- Lower Jurassic; 15-Midle Jurassic; 16- Lower Jurassic; 17- Dolomites of the Upper triasic; 18- Upper Triassic with evaporites; 19- Paleozoic (substratum of Ionian zone); 20- Verified paleological boundary; 21- Supposed geological boundary; 22- Verified lithological boundary; 23- Supposed lithological boundary; 24- Transgresive boundary; 25- Lithological marker; 26 Verified fault;27- Supposed fault; 28- Seismic reflector; 29- Normal attitude element; 30- Reversed attitude element; 31- Intersection of the seismic lines; 32- Trend of the Bouguer Anomaly; 33- Bouguer anomaly; 34- Depth wells.

Fig. 24. Reflection seismic line: Divjaka brachianticline in Peri-Adriatic Depression.

Fig. 24-b. Reflection seismic line: Divjaka brachianticline in Peri-Adriatic Depression.

Fig. 25. Paleomagnetic Declinations Map of the External Albanides (Kisel C. et al. 1994).

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JOURNAL OF THE BALKAN GEOPHYSICAL SOCIETY, Vol. 12, No. 1, December 2009, p.9-30, 27 figs, 1 table.

Geophysical outlook on structure of the Albanides

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Abstract: *The Albanides represent the assemblage of the geological structures in the territory of Albania. This paper presents a review of the existing seismological, reflection seismic, gravity, magnetic, electrical, and geothermal information, and relates them to the geological structure of the Albanides. Two major paleogeographic domains form the Albanides. The Internal Albanides belong to the Subpelagonian Trough. The External Albanides develop out of the Western passive margin and continental shelf of the Adriatic plate. Regional gravity anomalies are attributed to the depth variation of the Moho discontinuity, and the block structure setting of the crust. The Albanides are interrupted by a system of longitudinal fractures in NW - SE direction and transversal fractures. Intensive Bouguer anomalies and turbulent magnetic field with weak anomalies characterize the ophiolithic belt of the Internal Albanides. These data favor the allochton character of ophiolites. The Internal and the External Albanides show a nape character. A common feature of Ionian and Kruja structural belts in External Albanides is their Westward thrusting. Two tectonic styles are observed in the Ionian zone, namely duplex and imbricate tectonics. Miocene and Pliocene molasses of Peri-Adriatic Depression cover the Western part of Ionian zone.*

Key words: *Albanides, Mediterranean Folded Belt, Geophysics.*

INTRODUCTION

Integrated regional geophysical studies have been performed for exploration of the Albanides, both on land and in the Adriatic Sea Continental Shelf. Seismological studies, gravity and magnetic surveys, reflection seismics, geothermal studies, radiometric investigations, vertical electric soundings and well logging are combined in this geophysical investigation. Here, only selected geophysical data are presented.

The Albanides, together with Dinarides to the North and Hellenides to the South, form the Southern branch of the Mediterranean Alpine Belt (Fig. 1), (Aubouen and Ndojaj, 1964; Aubouen, 1973; Biçoku and Papa, 1965; Biçoku, 2000; Bushati, 1988; Frasheri et al., 1999; I.G.S., 1983, 1985; Meço and Aliaj, 2000; Melo, 1986; Papa, 1970). This paper presents the outcome of the seismological, reflection seismics, gravity, magnetic, electrical, and geothermal surveys for Albanides, in the framework of geophysical and geological observations.

Two major paleogeographic domains form the Albanides: the Internal Albanides and the External Albanides (Fig. 2).

The Internal Albanides are of Triassic and Jurassic age (Kodra, 1987) and belong to the Subpelagonian Trough. They are characterized by the presence of the immense and intensively tectonized ophiolithic belt which expands from E to W as overthrust. There are two viewpoints about the placement of the ophiolites: The allochthon character of the ophiolithic nappe (Auboin, 1973; Cadet et al., 1980; Çollaku et al., 1992; Frasheri et al., 1995, 1996; Frasheri, 2000; Hoxha and Bushati, 1996; Hoxha, 2000; Hoxha and Avxhiu, 2000; Lubonja et al., 1968; Langora et al., 1983; Melo, 1986; Papa, 1993; Qirinxhi, 1970; Veizaj and Frasheri, 1996) and autochthon ophiolitic belt (Beccaluva et al., 1994; Gjata and Kodra, 1999, 2000; Kane et al., 1999; Kodra, 1987, 1978; Kodra et al., 1996, 2000; Robertson and Shallo, 2000; Shallo et al., 1989).

The External Albanides develop off the Western passive margin and continental shelf of the Adriatic plate. They are regular structural belts associated with overthrusting.

Geophysical data indicate that the Earth crust becomes thicker from Adriatic Sea towards Albanides (Bare et al., 1996; Dalipi, 1985, 1987; Dhima et al., 1996; Guri and Guri, 1996; Mëhillka et al., 1996, 1999; Nishani, 1985; Papa and Kondo, 1968; Seitaj et al., 1996; Valbona and Misha, 1987; Velaj, 1995; Xhufi and Canaj, 1999).

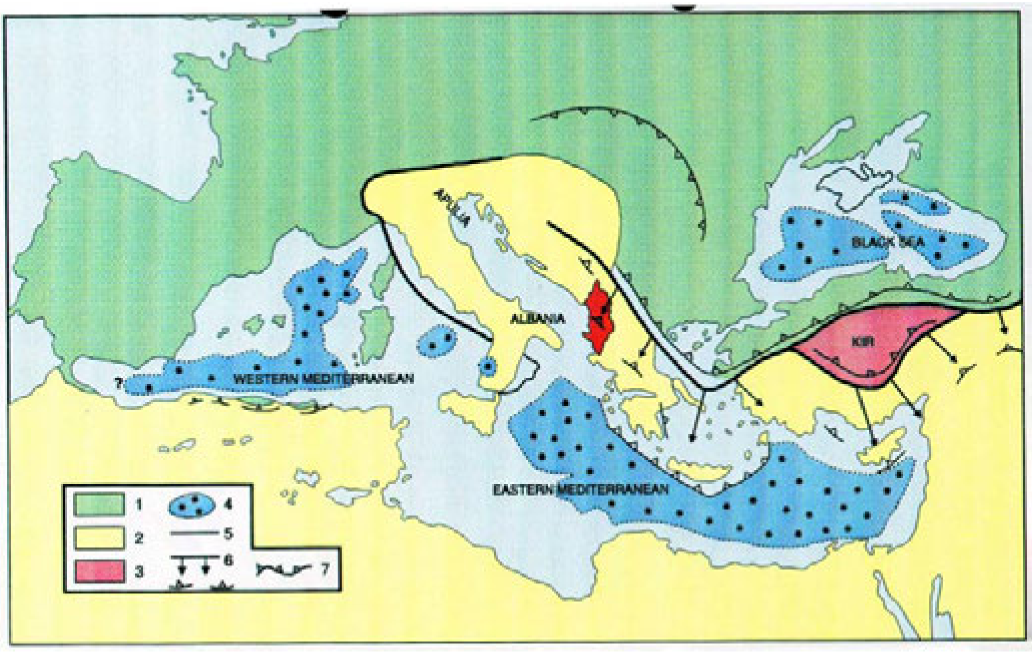


FIG. 1. Schematic Map of African Plate subduction under the Eurasia (After Ricou, 1986). Legend explanation: 1- Euro-Asiatic Continent; 2- African continent; 3- Kishir block; 4- Present Oceanic Basins; 5- Boundaries of Mesozoic Oceans; 6- Boundaries of Mesozoic Ocean and the Main Ophiolithic Nappes; 7- Troughs of present and past subduction.

The thickness of the sedimentary basin is 8-9 km near the Adriatic seashore and reaches 15 km in the Northwestern regions of Albania (Fig. 3) (Frasheri et al., 1998, 2000; Koçiu, 1987; Veizaj, 1995; Veizaj and Frasheri, 1996). The depth of the Moho discontinuity is 40 -50 km. The maximum thickness of the crust is observed at NW Albania. The regional gravity anomalies are attributed to the Moho undulations and the block structure of the crust. The latter is in accordance with the results from seismological studies (Figs. 3 and 4). Very deep faults in the NW-SE direction separate the tectonic zones. This tectonic setting of the deep crust in Albanides is also responsible for the scattering of the magnetic fields.

According to geological data, regional geophysical studies and based on structural criteria the Albanides consist of the zones shown on Table 1 (Fig. 2).

Intensive Bouguer anomalies and very turbulent magnetic field with weak anomalies (Bushati, 1988, 1997) (Figs. 5, 6 and 7), characterize the Mirdita ophiolithic belt of the Internal Albanides. According to these data, Kukes ultrabasic massif to the NE of the ophiolithic belt exhibits a maximum thickness of 14 km (Figs. 8, 10, 11 and 12). Towards West and Southeast, its thickness is reduced to 2 km. This supports the allochthon character of the ophiolithic belt and the overthrusting character of its Western contact, under which the formations of Krasta-Cukal zone, External Albanides are laid. The nape character between the Internal and the External Albanides develops in the W-SW direction. The splitting of the gravity and the magnetic anomalies in the central region of the Internal Albanides, at Shengjergji flysch corridor, is attributed to the presence of Diber -Elbasan - Vlora fault. This fault plays a significant role in the geology of Albanides (Figs. 4, 5, 6 and 7).

A common feature of the Ionian and Kruja belts in External Albanides is their Westward thrusting (Figs. 8, 10, 11 and 12). The presence of the Triassic evaporites sheet under the carbonates helped this thrusting process. According to the integrated geological-geophysical studies and deep wells, there are two tectonic styles, namely the Ionian and the duplex imbricate. Traverse faults separate the Ionian basin in several blocks. Additionally, the Southern Adriatic basin (limestone formations) is partly extended under the Sazani, Ionian and Kruja zones.

Peri-Adriatic Miocene and Pliocene deposits cover the Sazani, Ionian and partly Kruja tectonic zones. These Neogene molasses are placed transgressively over the older ones on top of the Ionian zone limestone (Fig. 20). The post-orogenic molasse deposits cover transgressively Mirdita and partially Krasta – Cukali tectonic zones in Korça and Burreli basins.

Table 1: The tectonic zones in Albania.

In Albanides	*equivalent in Hellenides*	*in Dinarides*
Internal Albanides		
Korabi	Pelagonian	Golia
Mirdita	Subpelagonian	Serbian
Gashi		Durmitor
External Albanides		
Albanian Alps	Parnas	High karst
Krasta-Cukali	Pindos	Budva
Kruja	Gavrovo	Dalmatian
Ionian	Ionian	
Sazani	Preapulian	
Peri Adriatic Depression		

EARTH CRUST

Seismological, gravity and magnetic data probed the crust (Figs. 2, 3, 4, 8 and 21) (Aliaj, 1987; Arapi, 1982; Bushati, 1988, 1997; Chiappini et al., 1996; Duka and Bushati, 1997; Frasheri et al., 1999; 2000; Koçiu, 1989; Langora et al., 1983; Lubonja et al., 1968; Lulo and Bushati, 2000; Sulstarova, 1987; Veizaj, 1995; Veizaj and Frasheri, 1996). The P-wave velocity in the deeper sedimentary crust ranges from 5.9 to 6.2-km/s, indicating more consolidated rocks (consolidated crust, Fig. 3). The regional gravity anomaly in Albanides is attributed to the Moho discontinuity undulations. The Bouguer gravity increases from Albanides to the Adriatic Sea Shelf (Figs. 5, 8 and 21). The geological-geophysical profiles Albanid-1 and Albanid-2 (Figs. 8 and 21) indicate that the depth to the Moho is minimum in the Adriatic sea region. The Moho discontinuity plunges from 25 km in the central part of the Adriatic Sea (Finetti and Morelli, 1972) to 43- 52 km at the Eastern Albanides. According to the interpretation of the regional magnetic anomalies, the top of the crystal basement plunges towards seashore and central Albania (Figs. 8 and 24).

In the Albanides there are four small Bouguer anomalies: two maximums and two minimums (Figs. 5 and 6). The first gravity maximum is observed over the Northeastern part of Mirdita and Korabi tectonic zones.

The second maximum, located at Vlora district to the Southwest of Albania, exhibits a strike which is sub-transversal to the geological structures of the Ionian tectonic zone. These regional gravity maximums indicate a crust thinning toward the Mirdita tectonic zone in Vlora district (Figs. 8 and 21). The same feature is observed in the Hellenides South of Mirdita ophiolithic belt (Cadet et al., 1980). The main gravity minimum extends from Southeast to the Northwest Albania. Another minimum is present at Alps tectonic zone.

These anomalies are attributed to the depth fluctuation of the Moho discontinuity and reveal a block setting of the crust, which is in accordance with the results of seismological studies (Fig. 2).

This tectonic setting of the deep crust in Albanides causes scattering of the magnetic fields (Fig. 7).

Geothermal energy of the Albanides is linked to deep faults. According to the geothermometer data, the water temperature reaches 220-270^{o}C at depth 12 – 13 km.

Earth crust setting of the Albanides controls the distribution of the geothermal energy. In the Heat Flow Density Map of Albania, the geothermal gradient varies from 15-21.3 mK/m in Pre-Adriatic Depression (Fig. 9) (Çermak et al., 1996; Frasheri 1993, 2000; Frasheri et al., 1995, 1996, 1999). According to the modeling results, the gradient decreases at depth greater then 20 Km (top of the crystal basement). In the ophiolithic belt (Northeast and Southeast Inner Albanides), the geothermal gradient reaches 36 mK/m. Lower gradient values are observed at depth greater than 12 Km (top of the Triassic salt deposits) (Fig. 8). On Albanid-1 and Albanid-2 profiles, the temperatures in the ophiolithic belt are higher than the ones in the sedimentary basin at the same depth.

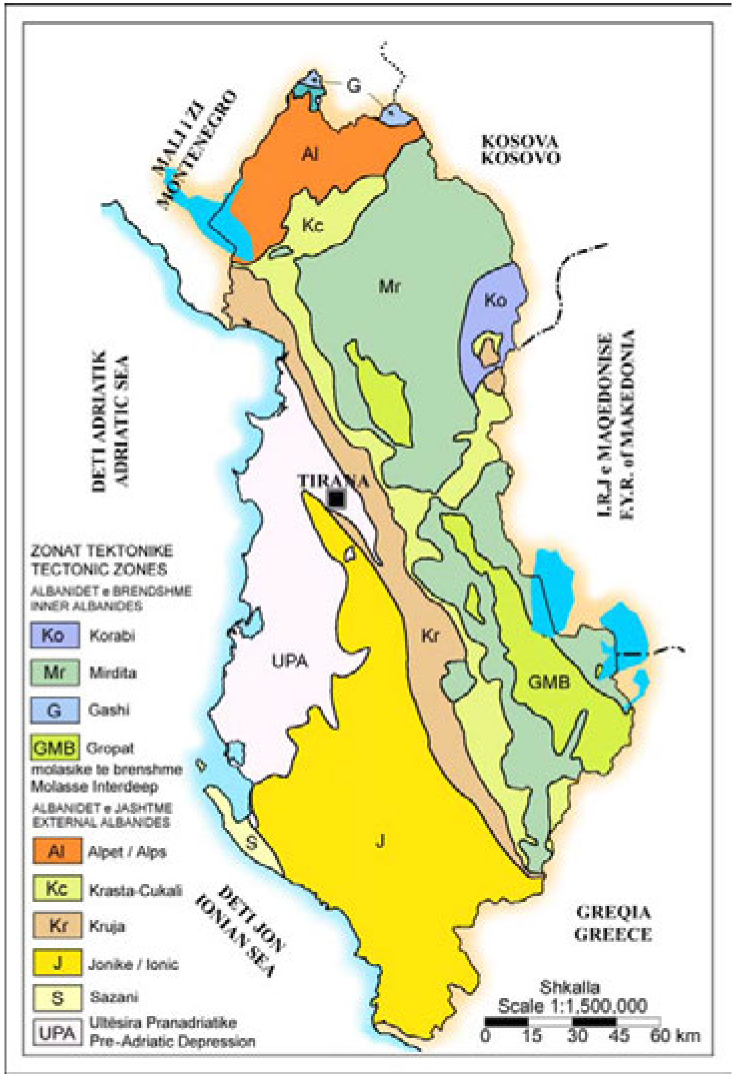


FIG. 2. Schematic Tectonic Map of Albania. (After Tectonic Map of Republic of Albania, at scale 1:200.000, 1985).

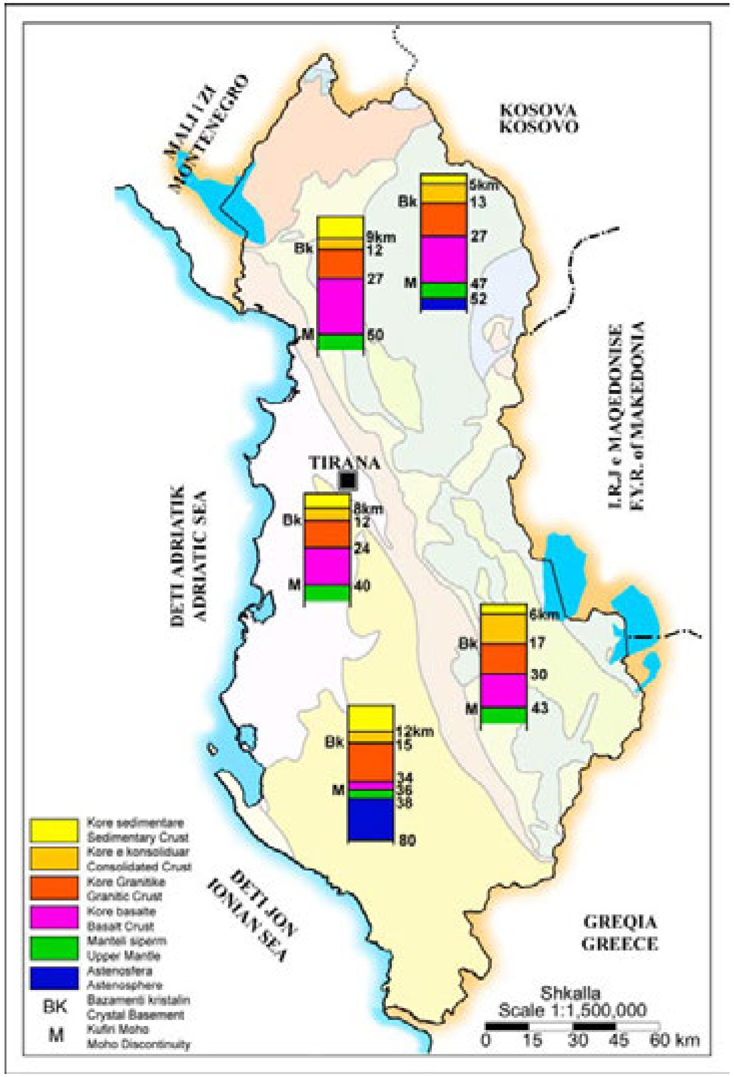


FIG. 3. Geologic structure of Earth's Crust and Upper mantle based on seismological studies (data taken from Koçiu, 1989). The numbers given in the columns express depths.

The Heat Flow Density Map (Fig. 9) reveals two characteristic features:

Firstly, the maximum value of the heat flow in the External Albanides is 42 mW/m^2. At the Eastern part of Albania, heat flow density values of 60 mW/m^2 are recorded. Since, the radiogenic heat from the ophiolites is very low, the higher heat flow in the ophiolithic belt is linked to deeper heat sources. According to the Albanid-1 profile, the granites of the crystal basement represent the potential heat source.

Secondly, in the ophiolithic belt there are hearths of higher heat flow density. Under the ophiolithic belt, the Moho depth decreases. Heat flow anomalies are controlled by deep transverse faults. These faults are associated with the geothermal fields. According to different geothermometers, the estimated aquifer temperature ranges from 144 to 270°C. Based on geothermal modeling, thermal waters can rise from 8-12 km deep, where temperature reaches 220°C.

These arguments favor the block character of the crystal basement. The depth of these blocks is small in Mirdita tectonic zone. Local heat hearths show the existence of transverse faults through which there is very high heat flow.

INTERNAL ALBANIDES

The tectonic zones of the Internal Albanides cover the Eastern part of Albania.

1. KORABI zone (K) is related to the Pelagonian zone in Hellenides and the Golia zone in Dinarides. In Korabi zone the Bouguer anomaly is normal (Fig. 4). The contact between Korabi and Mirdita zone coincides with the Ohrid-Qarishte-Qafe Murre-Kukes deep seismogenic structure.

This zone consists of the oldest formations of Albania, such as sandstones, schistose-conglomerate and metamorphic limestone of Silurian, Devonian and Carboniferous age, as well as sandstone-conglomerate and anhydrite of lower Permian-Cretaceous age. There are also volcanic and subvolcanic rocks of basic and acidic-alkaline content. In the Korabi zone, folds, thrust faults and cover rocks are present.

2. MIRDITA zone is related to the Subpelagonian zone in Hellenides and the Serbian zone in Dinarides. This wide belt extends from NW to SE., Three tectonic units were formed in Mirdita zone during different orogenic phases. The lower tectonic unit consists of ophiolites. Intensive Bouguer anomalies and turbulent magnetic field with weak anomalies characterize the ophiolithic belt of the Internal Albanides (Figs. 5, 6, 7, 8, 10, 11, 12 and 13).

There are three features in this anomalous belt:

- Firstly, this zone is divided in two parts, North and South of Shengjergji flysch corridor.
- Secondly, there are five gravity maximums (up to 105 mgal), along the anomalous chain from Tropoja-Kukesi ultrabasic massif in the North-East Albania to the Morava massif at South-East. In its Northern part, the anomalous belt takes a 60° to 70° turn to the North-East reaching the Dinarides ophiolithic belt.
- Thirdly, higher gravity anomalies are present in the Eastern belt over the ultrabasic massif. To the South, the ophiolithic belt exhibits limited thickness and it keeps developing Southwards in the Hellenides.

The Falko-Tirana-Bulqiza profile traverses all the tectonic zones of the Albanides (Figs. 8 and 13). Along this profile the maximum thickness of the Bulqiza ultrabasic massif is about 6 km. Two VES indicate that the Eastern part of this massif is dipping to the West. The abundance of high resistivity zones in these soundings indicates that the ultramaphic rocks are located at depths greater than 2500 m (Fig. 13).

The splitting of the gravity and the magnetic anomalies in the Shengjergji flysch corridor is caused by the presence of Diber -Elbasan - Vlora transverse fault, which has played a significant role in the geology of the Albanides. In Shengjergji flysch corridor, the absence of magnetic anomalies indicates that there are no ultrabasic rocks to the East of massif margins and under the flysch deposits (Fig. 14). The Bouguer anomaly in this region is due to the presence of a limestone anticline covered by the flysch. From vertical electrical soundings revealed the thickness of flysch deposits ranges from 2000 to 2500 m.

The thickness of the ophiolithic belt becomes 14 km in its Northeastern extreme (Kukes ultramaphic belt). Towards West and Southeast its thickness reduces to 2 km (Fig. 10). The Northwestern sector of the ophiolithic belt extends to the East of Shkodra (Figs. 10, 11 and 12). The intensity of gravity and magnetic anomalies increases from seashore towards the East. The gravity anomaly over the Gomsiqe ultrabasic massif is 12 mgal. It is four times smaller than the anomalies in the Eastern belt of ultramaphic massif. This indicates that the ophiolithic belt is thinner to the West.

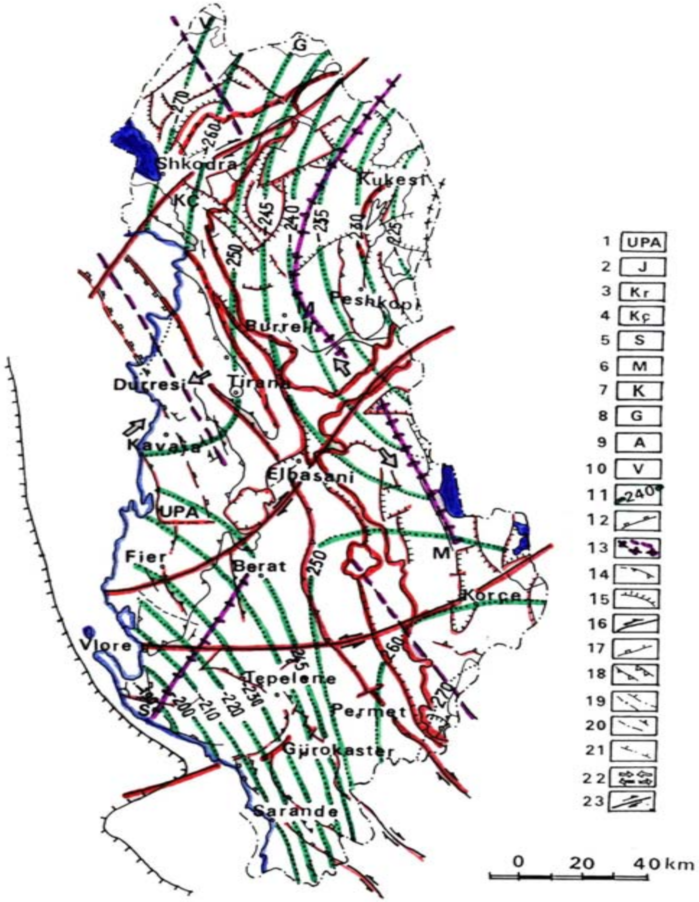


FIG. 5. The Complex Tectonic Map and Bouguer Anomaly map in the Albanides (3rd degree trend).

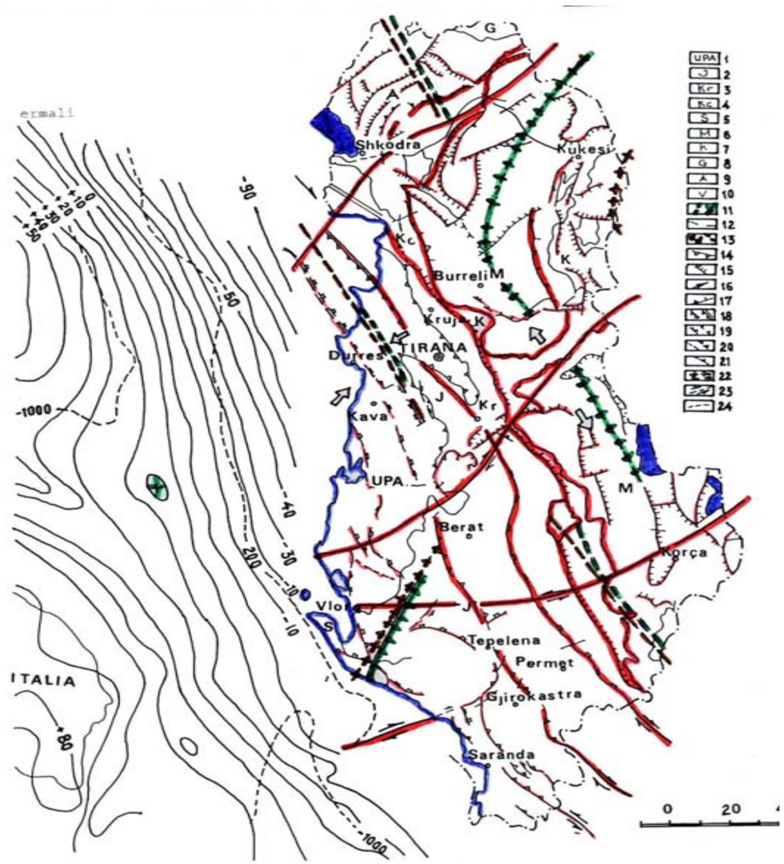


FIG. 6. The Complex Tectonic Map and axes of the Bouguer anomaly in the Albanides and in theAdriatic Sea continental plate.

Explanation of the legend for Figs. 5 and 6

1-Peri-Adriatic Depression; 2- Ionian zone; 3- Kruja zone; 4- Krasta-Cukali zone; 5- Sazani zone; 6- Mirdita zone; 7- Korabi zone; 8- Gashi zone; 9- Albanian Alps zone; 10- Vermoshi zone; 11- The axes of the Bouguer Residual Anomalies, positive (a) and negative (b); 12- Isoanomals of the Bouguer Anomaly in the Adriatic and Ionian Sea (after Morelli C et al. 1969); 13- The axes of the up-left and down-left of the Mante; 14- Boundary of the Peri-Adriatic Depression with angular discordance; 15- Normal fault; 16- Pressure; 17- Limit of deformed envelopment during the neotectonic period; 18- Overthrust; 19- Flexure; 20- Flexure and faults based on geophysical data; 21- Inactive overthrust; 22- Compression (a) and (b) extension zones; 23- Seismogenic deep uplift; 24- Isobaths of the water depth, in meters.

The magnetic anomaly present in the profile, shows that here the ophiolites contact dips to the East with an angle about 45°. This interpretation supports the argument that Mirdita zone covers the formations of Krasta-Cukal zone at the Western contact of the Mirdita ophiolithic belt. The seismological studies do not support the presence of any deep fracture.

VES carried out in Burreli indicate that the thickness of the neogene molasses is approximately 1500 m in the Northern part of the basin (Fig. 15). A high resistivity layer under the neogene formations is attributed to the ophiolites. The thickness of the 100 Ohmm resistivity layer under the ophiolites is 500 m. This layer corresponds to Triassic limestone. The seismic profile through this basin shows that the layer under neogene deposits without internal reflections, is attributed to the ophiolithic formation. Under this layer, the section exhibits many horizontal seismic reflections, which implies the presence of stratified formations (Fig. 16). At greater depths seismological data indicate a P-wave velocity reversal in Mirdita zone (Fig. 17).

These observations indicate that the ophiolithic belt of the Albanides is genetically unique and tectonically split into two sub-belts. Geophysical data give the arguments for the overthrust character of ophiolithic belt.

3. GASHI zone (G). Beyond its border it continues into the Durmitori zone of the Dinarides. This zone includes metamorphic rocks, terrigeneous rocks, limestone, metamorphic volcanites, basic intermediate and acidic rocks.

EXTERNAL ALBANIDES

The tectonic zones of the External Albanides are present in Western Albania.

1. ALPS zone (A) is related to the Parnas zone of the Hellenides and the High Karst one of the Dinarides. In this zone the oldest rocks are the Permian sandstones and the conglomerates. In general, Alps consist of limestone monoclines, combined with smaller anticlines. A regional gravity minimum is observed in the Alps zone. Local gravity maximums are present over the carbonate structures (Fig. 18).

2.KRASTA-CUKALI zone (K-C) is related to the Pindos zone of the Hellenides and the Budva zone of the Dinarides. Krasta subzone is a narrow belt from Shkodra city, Northwest Albania to Leskovik city Southeast Albania. This zone is located between the Internal and External Albanides. The profile in Figure 18 crosses the Northwestern margin of ophiolithic belt, the Cukali zone and reaches to the Albanian Alps. The Shkoder–Peje transverse fault interrupts this profile. Residual Bouguer anomaly increases to the Southeast along this profile. This increase is attributed to:

Firstly, the increased thickness of the Triassic to Cretaceous limestone formations in Cukali and Mirdita zones towards their contact with Alps.

Secondly, the existence of ophiolites covered by Cukali formations.

Thirdly, the presence of higher density Paleozoic formations.

3. KRUJA zone (K) continues to the North as Dalmate zone of the Dinarides and to the South as Gavrovo zone of the Hellenides. The reflector at 2.3-2.5 s, partially parallel to the shallower ones, is attributed to the top of the limestone (Fig. 19). The reflector 1-1 is attributed to the top of J-C salts which are placed on top of the flysch. The seismic section shows a deep regional overthrust feature. In this case, the 2-2 reflection originates from the top of the flysch. Thus, carbonate structures underneath the flysch show perspectives for oil and gas.

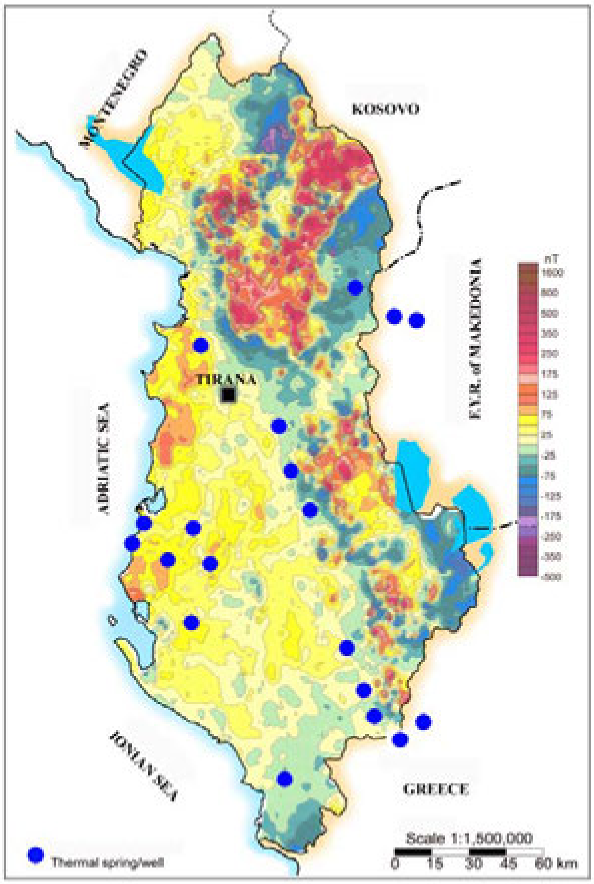


FIG. 7. Total Magnetic Field map of Albania (After Bushati, 1987).

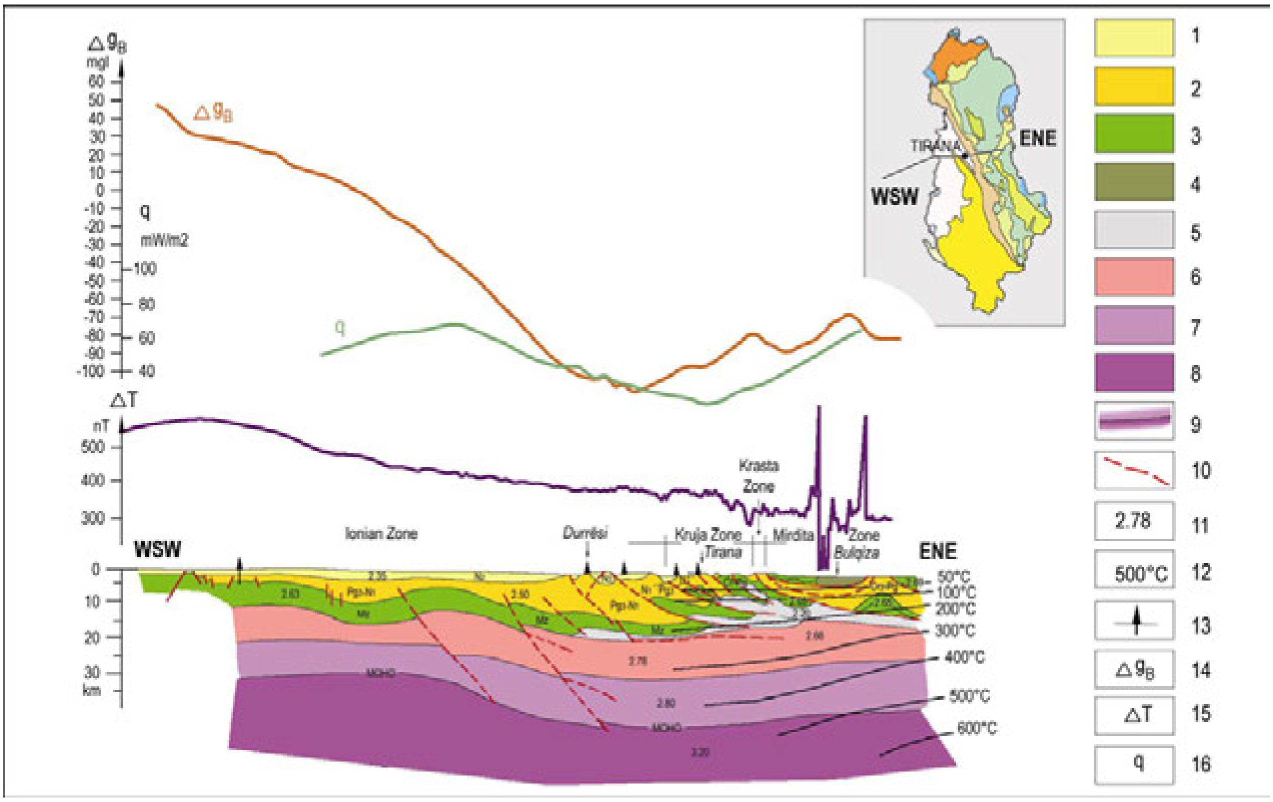


Fig. 8. Geological-geophysical profile Albanid-2: Falco Adriatic Sea- Durres-Tirana- Peshkopi (The gravity data for the Adriatic Sea after Richetti, 1980).

Legend: 1. Pliocene Substratum; 2- Substratum of Serravalian Molasses-Paleogenic flysch (Pg_3) over the limestone; 3- Lower - Middle Paleogene (Pg_{1-2}) - Triassic carbonatic facies; 4- Ultrabasic rocks; 5- Permian evaporites; 6- Crystal basement; 7. The basalt Earth Crust 8. Mantle; 9- Moho Discontinuity; 10. Uplift; 11- Density value of the rocks, in g/cm^3; 12- Temperature, in ^oC; 13. Deep wells; 14. Δg_B- Bouguer Gravity Anomaly; 15. Total Magnetic Field Anomaly; 16. Q- Heat Flow Density.

4. IONIAN zone (Io) in the Southwest Albania continues in Greece. It is the largest zone of External Albanides which has been developed as a deep pelagic trough since upper Triassic (Figs. 20.a, b and c). The Permian- Triassic evaporites are the oldest rocks of this zone. This formation is covered by thick deposits of upper Triassic- lower Jurassic dolomitic limestone and Jurassic-Cretaceous-Paleogene pelagic cherty limestone. Limestones are covered by Paleogene flysch, Aquitanian flyschoidal formations and a thin layer of Burdigalian-Helvetian and partially of Serravalian- Tortonian formations, which mainly fill the synclinal belts. Burdigalian deposits are placed in angle discordance over anticline belts. This indicates a two-stage structure.

Liassing rifting affected External Albanides including Ionian zone. In the latter, three tectonic blocks were formed which correspond to the following structural belts:

a. Berati anticline belt, in the eastern margin of the zone.

b. Kurveleshi anticline belt, in the central part, according to evidence from reflection seismics which image the carbonates.

c. Çika anticline belt, which represents the Western edge of the Ionian zone.

By combining the geological-geophysical data many anticlines were delineated in the carbonate deposits within these tectonic belts. Longitudinal faults affect the Western flanks of these structures.

The Berati anticline belt

The seismic acquisition on this belt was performed by different techniques. The time sections are very complicated. Occasionally, some reflections from the top of the limestones are recorded in certain lines, especially in the centre and to the West, probably because limestones in this zone are deep and faulted. According to the seismic data, limestones in the centre are markedly broken.

This conclusion is well supported by deep wells, drilled in Sqepur- Bistrovica area.

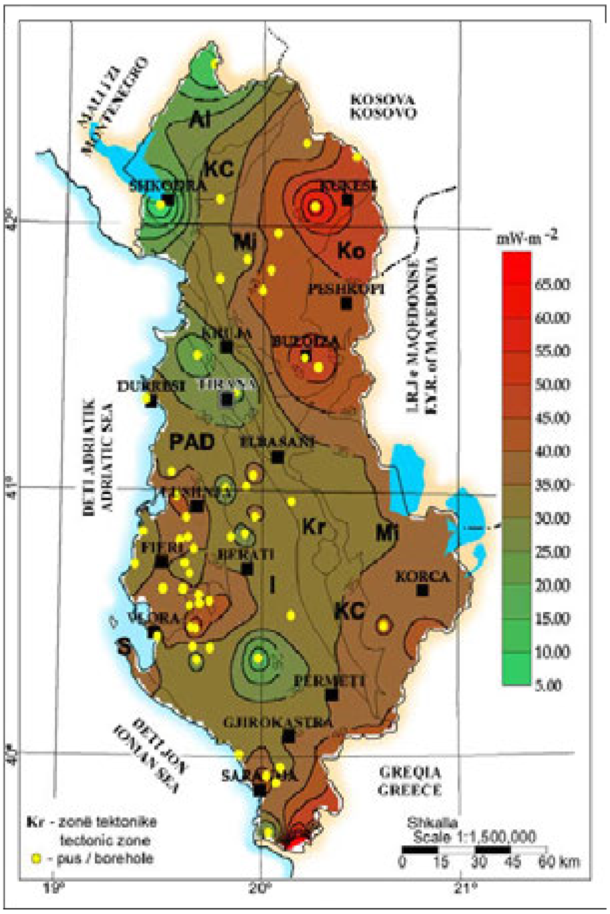


Fig. 9. Heat Flow Density Map of Albania (After Frashëri et al., 1995).

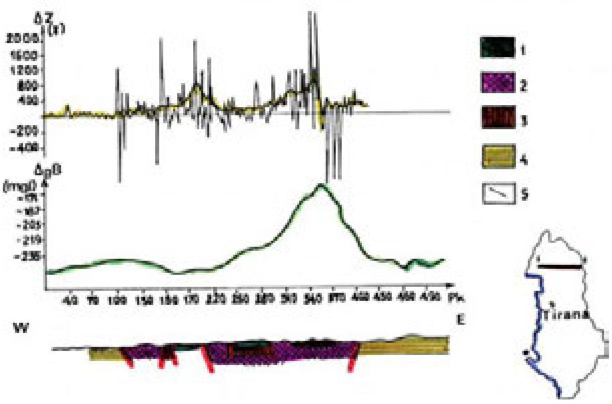


Fig. 10. Geological-geophysical Shkodër-Kukës profile.

Legend: 1-Effusive rocks; 2- Ultrabasic rocks; 3-Gabbro; 4- Sedimentary formation; 5- Disjunctive tectonic.

Kurveleshi anticline belt

Here, we refer mainly to carbonate formations. The Kurveleshi belt consists of structures associated with developed tectonics and thrusting (5-10 km horizontal displacement) to the West, as well as diapirism to the east. The regional seismic section II-II, which crosses the Ionian zone, from West to east, clearly depicts perspective oil and gas-bearing structures.

Çika anticline belt

Çika anticline belt is constructed mainly by prolonged structures associated with evaporates outcropping in Xara, Fterra, Çika etc. Seismic surveys in this belt date back to the start of oil exploration in Albania and still continue today. Earlier one fold coverage acquisition techniques have been replaced in the last years by multiple fold coverage ones. Two main tectonic styles characterize the Ionian zone: Duplex tectonic and imbricate tectonic styles. The back thrust faults have been caused by retrotectonic phenomena. The geodynamics of the Ionian zone is related to the evolution of the transversal faults. These faults divided the Ionian basin in several blocks, since lower and middle Jurassic rifting. The periodical tectonic movement of the transverse faults has played an important role to this overthrusting phenomenon.

The regional seismic sections clearly show that during the structuring process of the Ionian zone, (upper Oligocene to Langhian), the Sazani zone as well as the underlying of Southern Adriatic basin limestone were formed (Figs. 22 and 23).

5. SAZANI zone is the continuation of the Apulian platform. It consists of a thick Cretaceous-Eocene limestone and dolomite formation. Marly deposits of Burdigalian age are placed transgressively over carbonate formations (Fig. 22).

The interpretation of the recent geological, seismic and gravity data provides a new structural model. The External Albanides are in compression tectonic regime since upper Jurassic-Cretaceous periods. Only to the West, the Apulian zone and the South Adriatic basin exhibit continuous extension. South-Eastern External Albanides are characterized by a great Southwestward overthrust of the anticline chains and transverse faults.

Evaporites represent the lubrication substratum during this overthrusting movement. Regional back thrusting is also observed in the Ionian and Sazani zones. These structural-tectonic models indicate the interference of South-Westward over thrusting with secondary and more recent North-Westwards overthrusting.

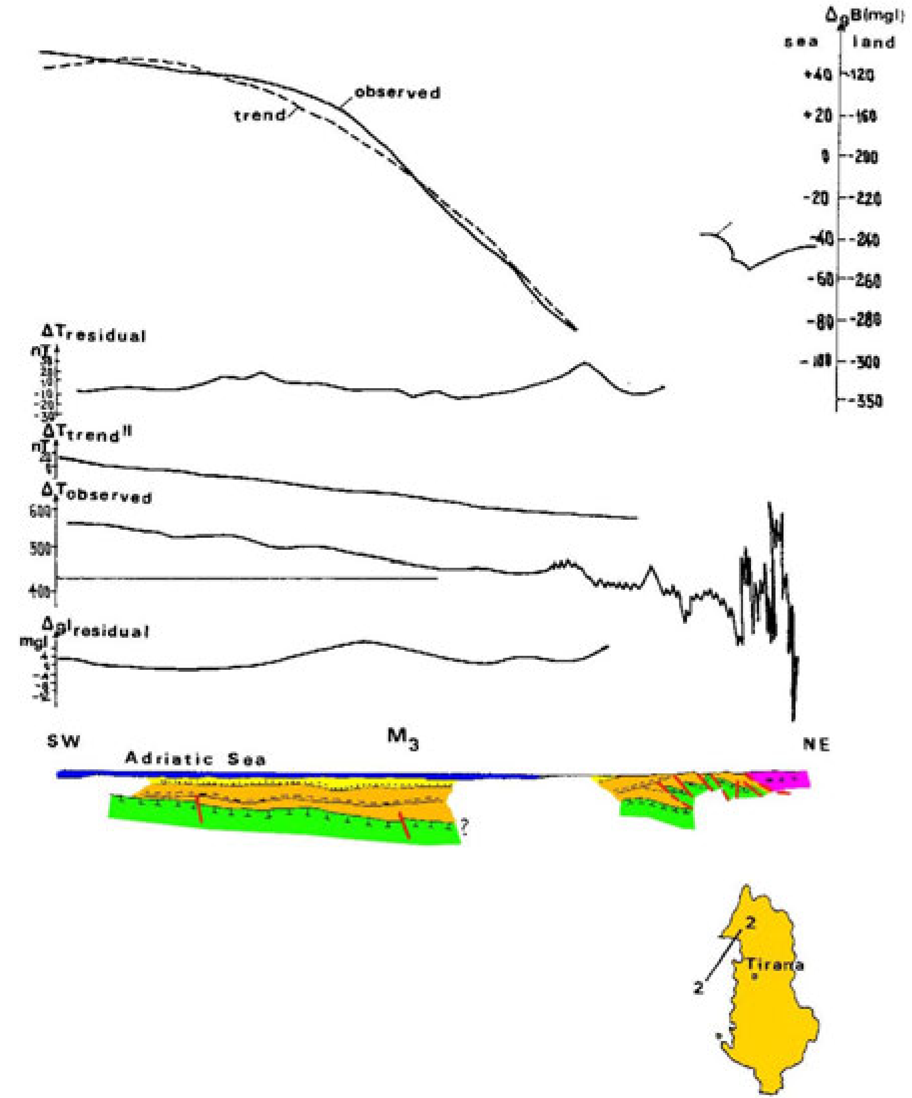


Fig. 11. Geological- geophysical profile: Adriatic Sea- Vrith.

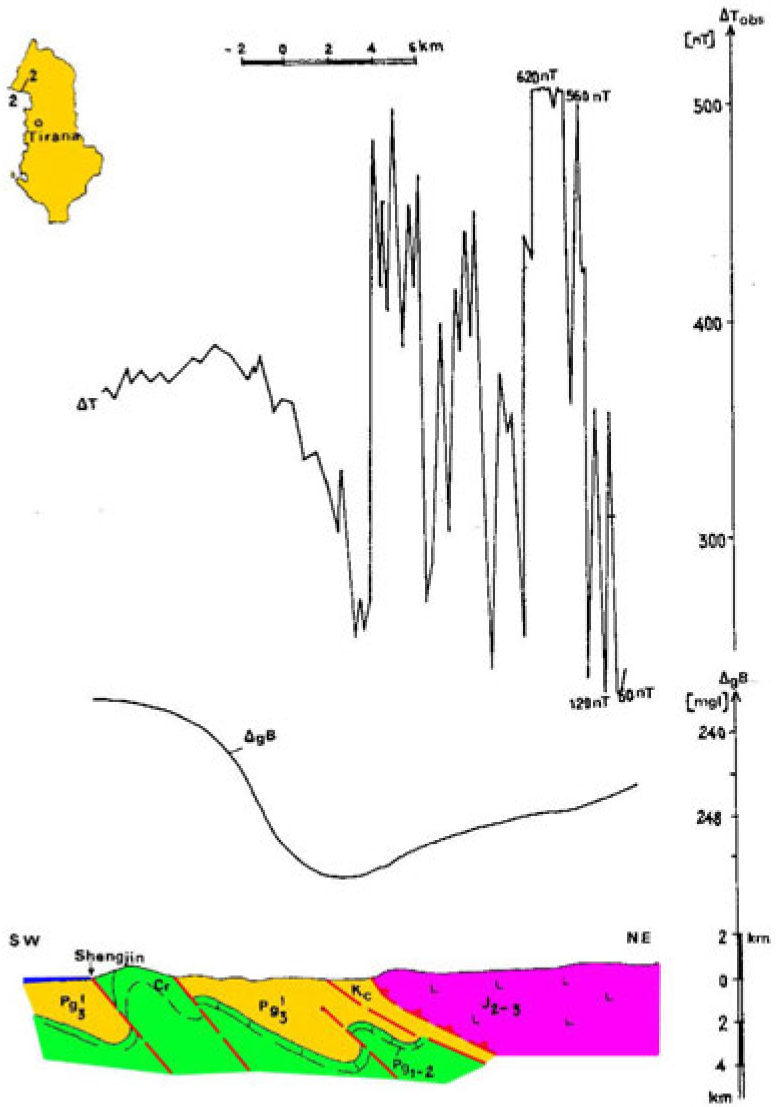


Fig. 12. Geological-geophysical profile: Shëngjin- Vrith.

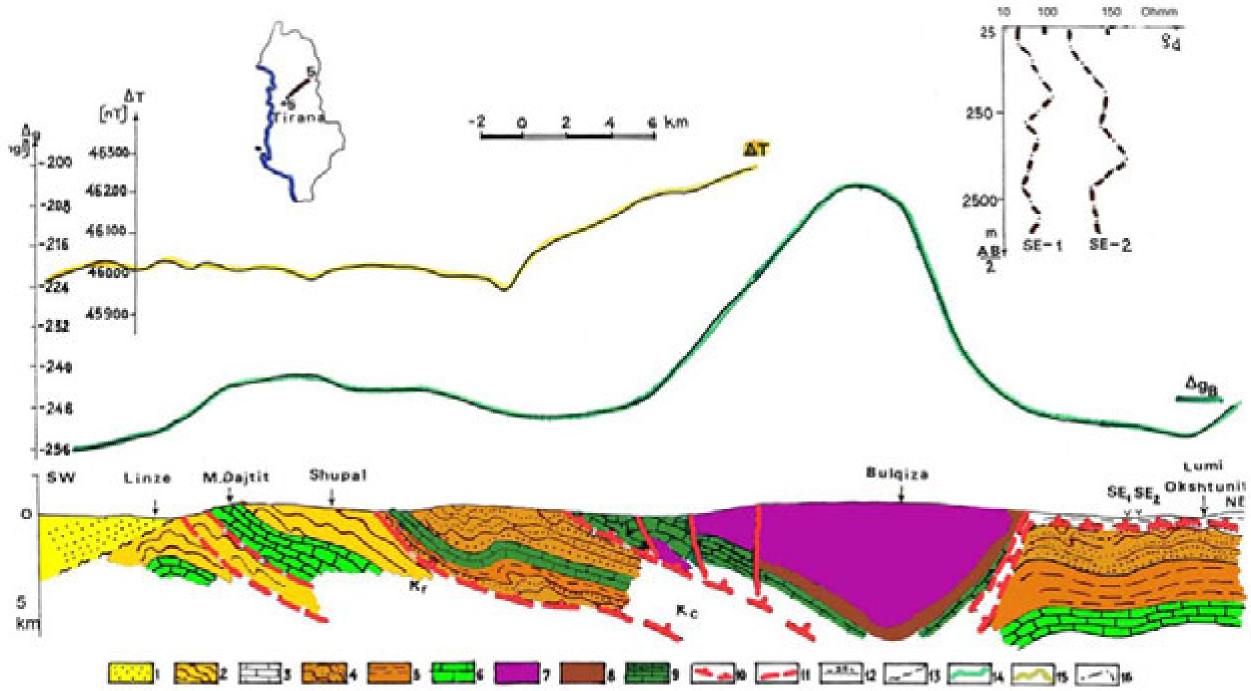


Fig. 13. Geological-geophysical profile: Tirana- Bulqizë- Shupenzë.

Legend: 1-Terrigeneous Tortonian formations; 2- Paleogene flysch formations; 3- Upper Cretaceous-Paleogene Limestone; 4- Titonian- lower Cretaceous flysch formations; 5- Upper Triassic- lower Triassic limestone; 6- Radiolaritic limestone with silic radiolarities; 7- Ultrabasic rocks; 8- Effusive rocks; 9- Limestone with siliceous of middle Triassic- lower Jurassic; 10- Overthrust plane; 11- Uplift tectonic; 12- Electrical sounding centers; 13- Unconformity; 14- Bouguer anomaly; 15- Magnetic anomaly; 16- Electrical sounding resistivity curve.

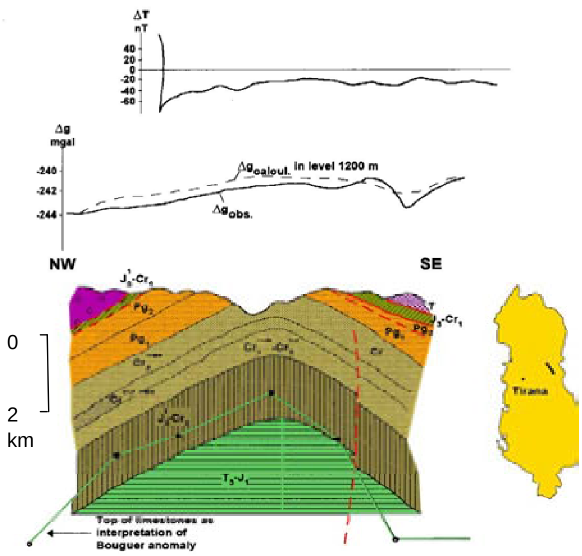
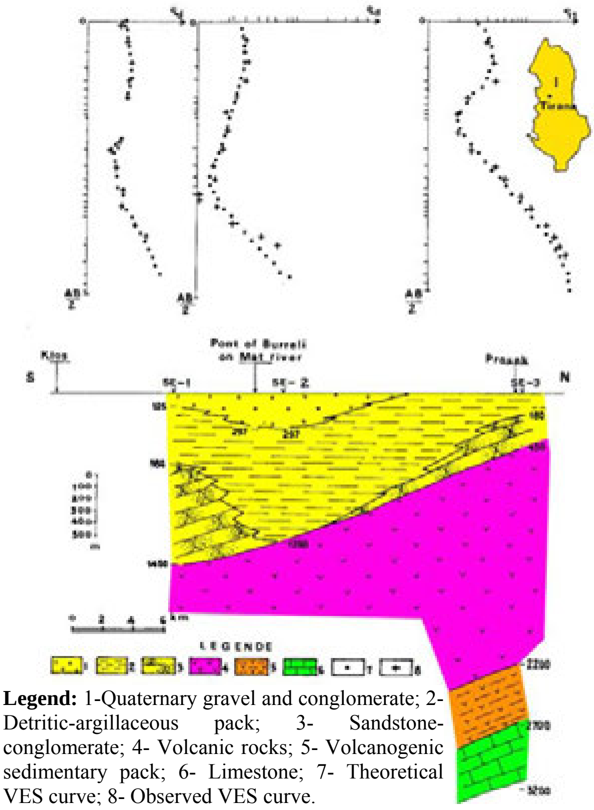


Fig. 14. Geological-geophysical profile through Peleogene and Cretaceous flysch exposures (Okshtun window).

Abbreviations: T- Triassic; J- Jurassic, Cr- Cretaceous, Pg- Paleogene.



Legend: 1-Quaternary gravel and conglomerate; 2- Detritic-argillaceous pack; 3- Sandstone-conglomerate; 4- Volcanic rocks; 5- Volcanogenic sedimentary pack; 6- Limestone; 7- Theoretical VES curve; 8- Observed VES curve.

Fig. 15. Geoelectrical profile: Klos-Prosek over the Burreli Neogenes.

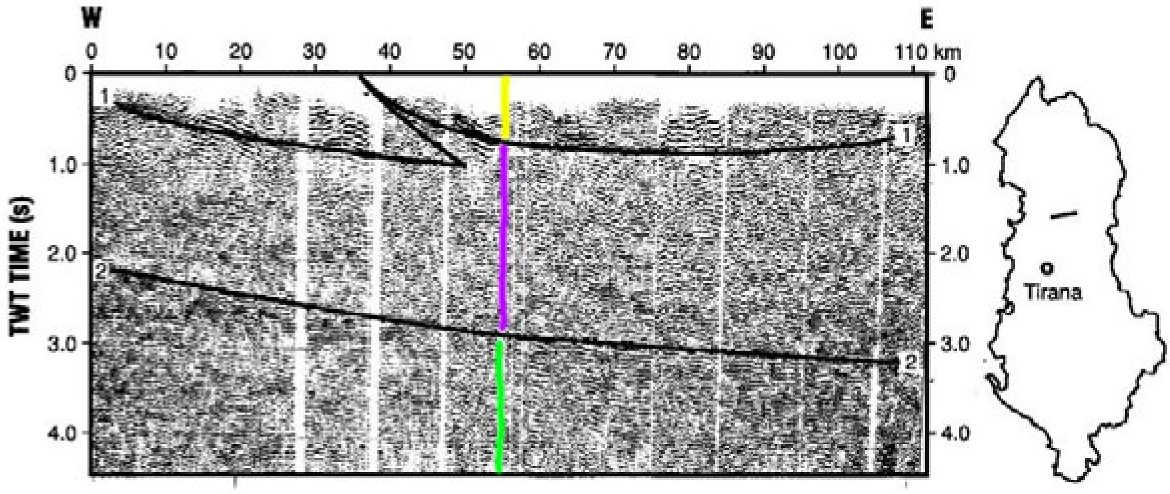


Fig. 16. Seismic reflection line in the Burreli Neogenes.

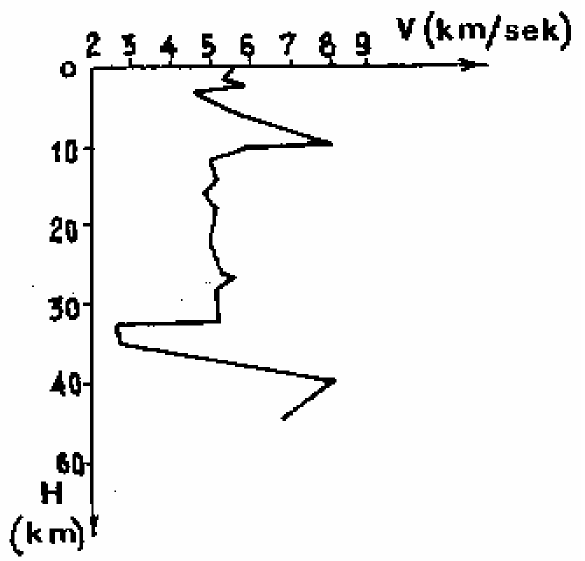


Fig. 17. Seismic P wave velocity reversal deduced from seismological data (Koçiu, 1989).

6. PERI-ADRIATIC DEPRESSION

Overlying Peri-Adriatic Depression covers the Ionian, Sazani and partly Kruja tectonic zones. This is a depression filled with middle Miocene and Pliocene molasses, which are mainly covered by Quaternary deposits (Figs. 8, 20, 21 and 24). Tortonian- Messinian- Pliocene molasses consist of a considerable number of sandy-clay mega-sequences. From SE to NW, the thickness of the molasses increases, reaching 5000 m. Sandstone-clay deposits of Serravalian and Tortonian age are placed transgressively over the oldest ones, including limestone formations and they create a two-stage structure (Figs. 20 and 24).

In the Ionian, Kruja and Sazani zones, the thrusting and back thrusting degree of the structures and structural chains increased during the molasses cycle. This phenomenon often led to the formation of tectonic blocks within the carbonate section, and to the partial or complete development of the anticline structures.

The Albanian sedimentary basin extends even in the Adriatic shelf where local Bouguer and magnetic anomalies are observed (Figs. 8 and 14) (Richetti, 1980). These local gravity maximums coincide with magnetic field minimums. Some researches have reached to the conclusion that the Apulian platform is tectonically quiet.

PALEOMAGNETIC REVIEW ON DYNAMIC EVOLUTION OF ALBANIDES

The dynamic evolution of the Albanides is recorded in the paleomagnetic data, collected from the paleomagnetic studies in Albania (Frasheri and Bushati 1995, Frasheri et al., 1995; Kane et al., 1999; Kissel et al., 1992, 1994, 1995; Mauritsch et al., 1991, 1994; Mauritsch, 2000).

Paleomagnetic studies show that the Ionian and Kruja zones encountered a joint 45^o-50^o clockwise rotation, during and after Eocene-Oligocene periods. This is the outcome of two distinct 25^o rotations in the middle Miocene up to Plio-Pleistocene. Ionian and Kruja zones as well as the zones the central and Northern Albania divided by Vlora- Elbasan- Diber encountered similar rotations. Thus, the evolution of the External Albanides from upper Eocene up to present is probably continuous (Fig. 25).

The upper Miocene formations in the Peri-Adriatic Depression indicate that the External Albanides encountered a 10-15^o clockwise

rotation between Oligocene and upper Miocene. Also, Pliocene clays at the Central Albania indicate a 10^{o} rotation of the External Albanides during the upper Miocene and lower-middle Pliocene. Additionally, a clockwise rotation of the External and Internal Albanides has been evidenced. This rotation is younger than Tortonian, compared to the general apparent polar displacement path from the Africa and Eurasia (Figs. 26 and 27). Renz and Kakariq Eocene limestone anticlines in the Shkoder-Peje transverse zone, exhibit a 31^{o} rotation. Consequently, the declination of these two anticlines is smaller than the declination of the Eocene limestone in the Central Albania (18^{o}). These two anticlines undertook two distinct rotations. One rotation is clockwise (50^{o}) which is typical for External Albanides. The second rotation is counterclockwise (25^{o}).

Limestone samples from Albanian Alps at Selca area, North of the Shkoder-Peje transverse, indicate a 20^{o} counterclockwise rotation which is the case for South Dinarides.

Similar counterclockwise rotation is also recorded on Jurassic limestone present at the South shore of Shkodra lake. This indicates that both formations belong to the same tectonic zone. Shkoder-Peje transverse area has great tectonic influence over Cukali subzone, where rotation changes from counterclockwise to clockwise be observed in very short distances. In the North-Western edge of the Mirdita zone, at the Komani ophiolithic belt, declinations show the clockwise rotation of the effusive and sedimentary rocks.

Thus, Shkoder-Peje lineament defines a transition zone which separates the Albanian Alps and the Dinarides (counterclockwise rotation), from Albanides and Hellenides (clockwise rotation).

Magneto-biostratigraphic studies performed at Kçira area in Mirdita zone, show alternation of normal and inverse magnetization in the Spathian-Anisian section. Kçira Pole presents affinity with Western Gondwana after restoration for the Neogenes (Muttoni et al., 1996).

Samples from the ophiolithic belt in Internal Albanides (Qafëzezi South of Korça district through Kalimashi area in Kukësi ultrabasic massif NE Albania) exhibit the same declination as the ones from the Hellenides ophiolithic belt.

CONCLUSIONS

1. Albanides, the assemblage of geologic structures, which extend in the Albanian territory, between the Dinarides and the Hellenides consist of two major Internal Albanides and the External Albanides.

2. Earth Crust of the Albanides exhibits a block structure controlled by a system of NW-SE longitudinal faults as well as transverse ones. Some of these faults separate even the tectonic zones and are linked to the geothermal fields of the Albanides.

3. The Mirdita ophiolithic complex causes a gravity anomaly chain and a turbulent magnetic field of relatively low intensity. This geophysical evidence supports the allochthon character of ophiolithic belt. According to the gravity data the thickness of the ophiolithic belt varies from 6 to 14 km to the East (ultrabasic massifs), while it is less than 2 km to the West.

4. The tectonic zones of the External Albanides are in compression tectonic regime since the upper Jurassic-Cretaceous. The Western part of external Albanides, the Apulian zone and the South Adriatic basin are in continuous extension.

5. The geophysical data show that the orogene front of the Albanides is in the Adriatic Sea. The Ionian and Sazani zones in the Adriatic Sea Shelf extend over the Apulian platform.

6. The Internal and the External Albanides have a Southwestward nappe character.

7. Paleomagnetic studies have demonstrated that assemblage of the Albanides margin encountered a clockwise rotation of about 45^{o}, after upper Oligocene. This rotation happened in two phases. This is also the case for the Western margin of the Hellenides. Shkoder-Peje transverse fault represents a transition zone between the clockwise rotation of the Albanides and Hellenides and the counterclockwise one of the Dinarides. For the rotation pole located at Shkoder-Peje transverse fault in Southern Albania, the horizontal displacement is about 173 Km.

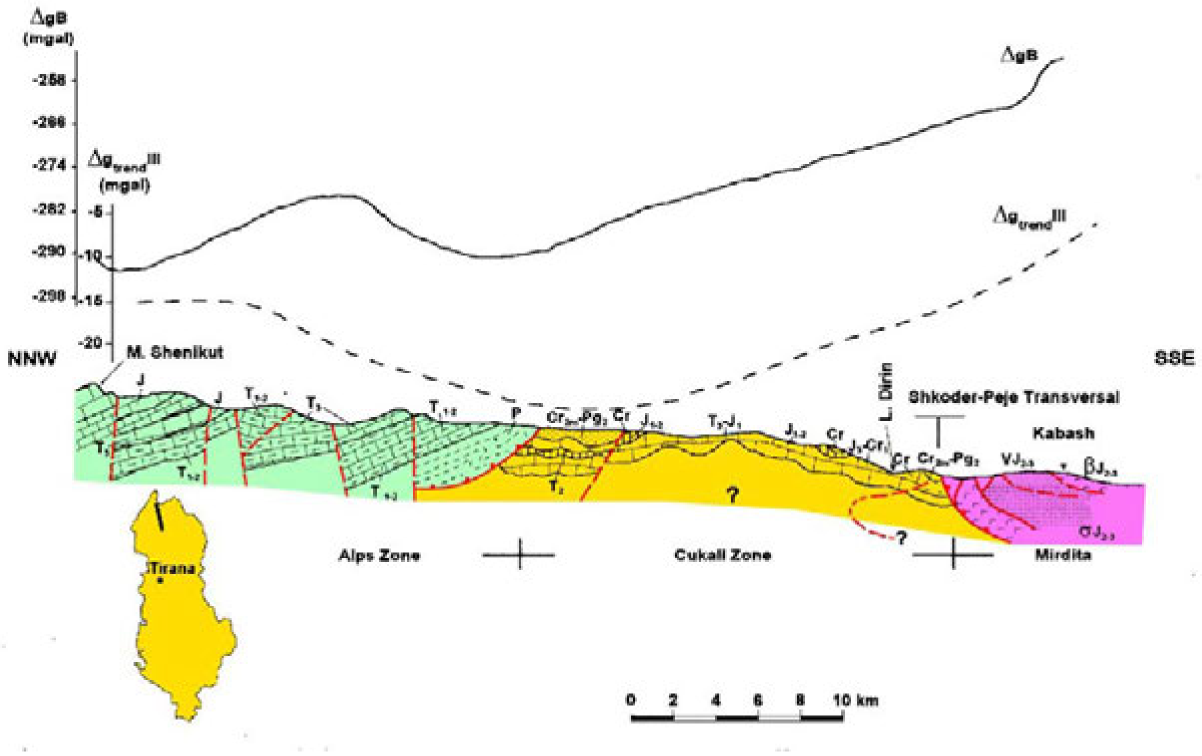


Fig. 18. Geological-geophysical profile: Alps-Cukali-Mirdita zones, over the Shkodër- Pejë Transverse.

Legend: as in Fig. 14.

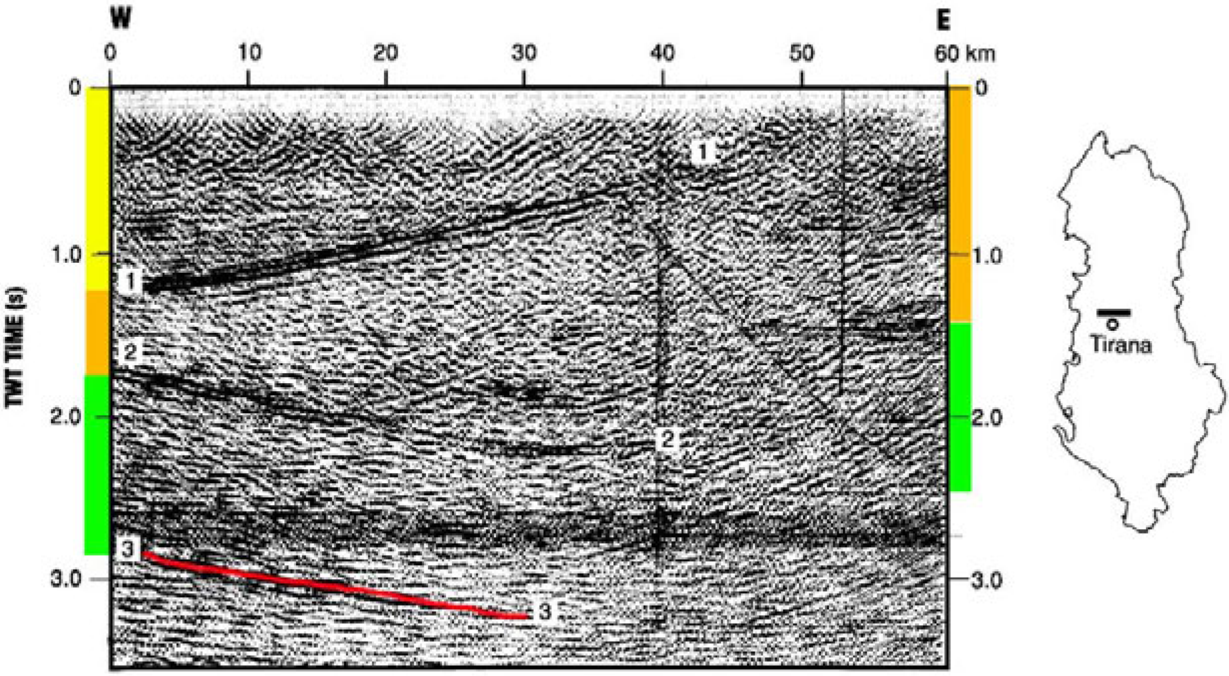


Fig. 19. Reflection seismic line in the Tirana Neogene Depression.

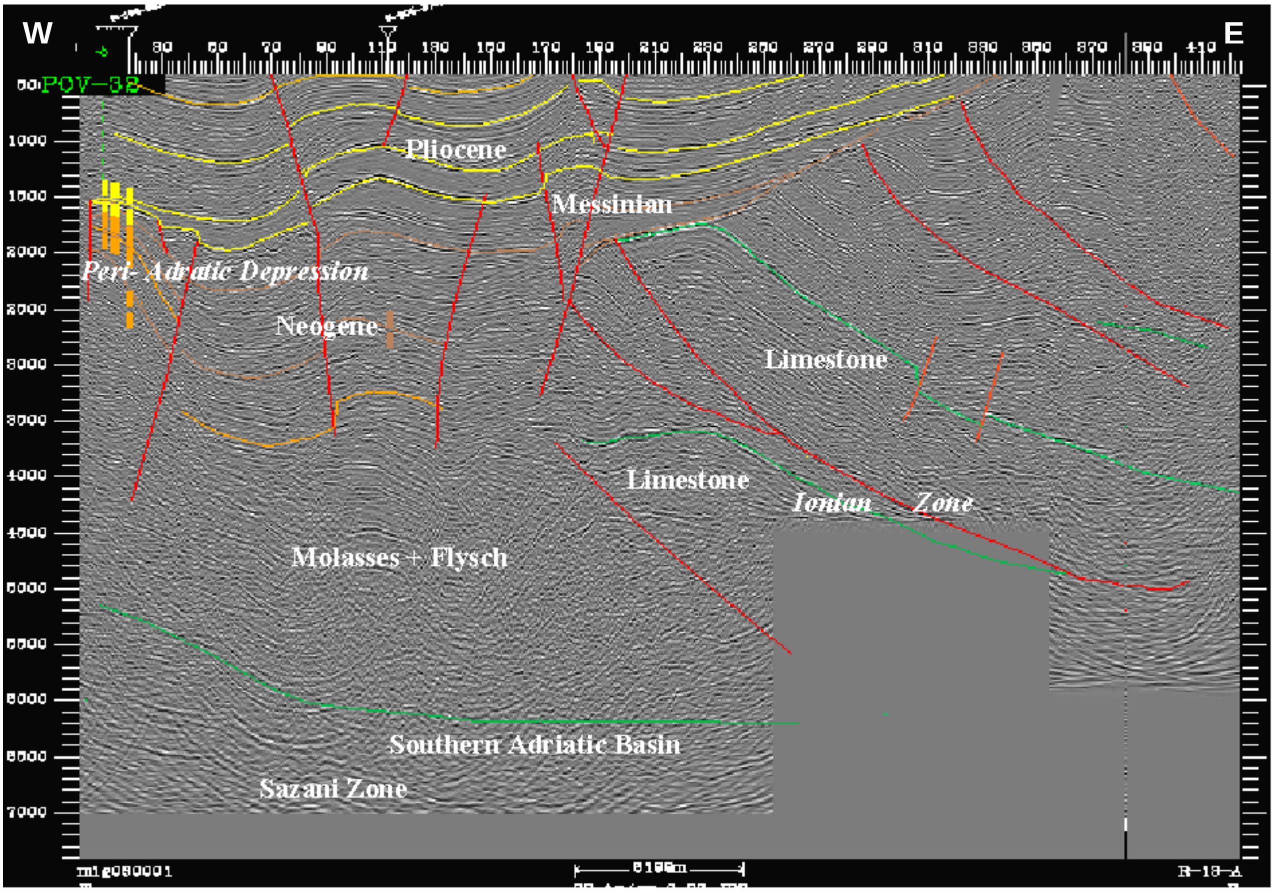


Fig. 20. Regional seismic reflection line in Ionian and Peri-Adriatic Depression. The vertical axis denotes two way travel time in ms (maximum time 7500 ms). The length of the line is approximately 35000 m.

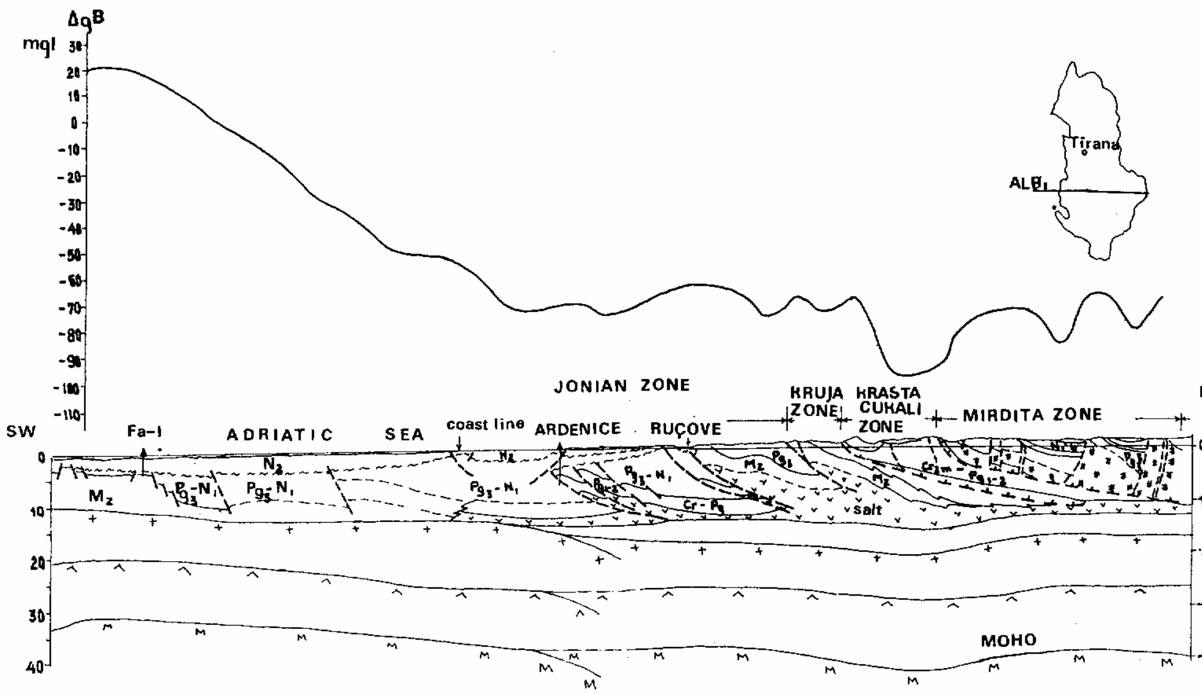


Fig. 21. Geological-geophysical profile Albanid-1: Falco Adriatic Sea- Seman-Kuçovë- Bilisht (The gravity data for the Adriatic Sea after Richetti, 1980).

Legend: as in the Fig. 14.

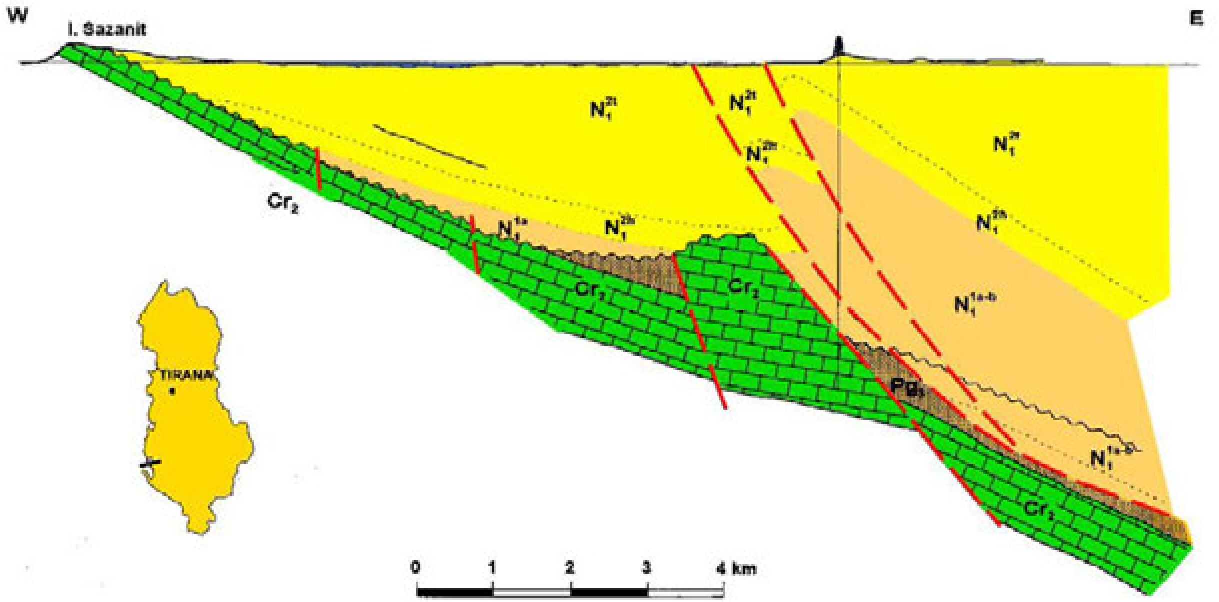


Fig. 22. Geological profile of Sazani-Zvërnec in Vlora district. Legend as in Fig. 14.

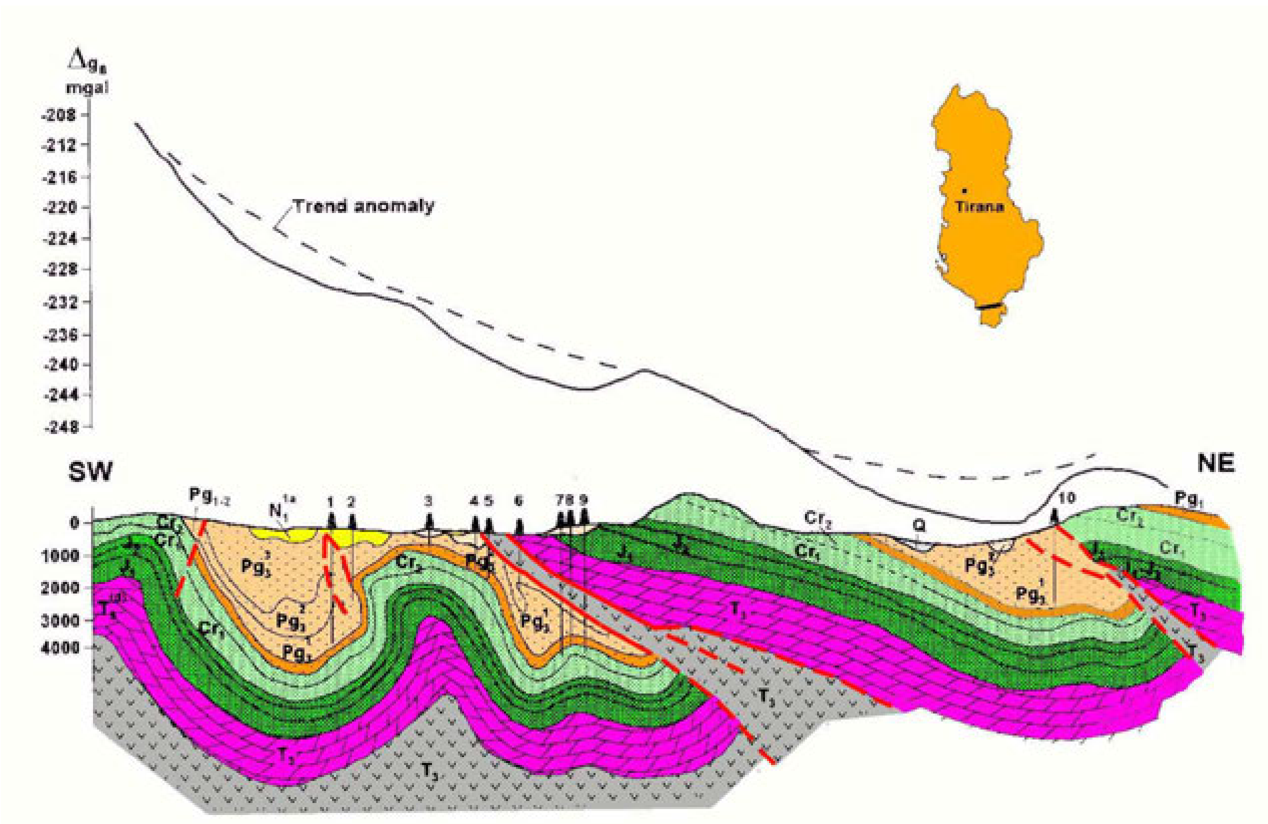


Fig. 23. Geological-geophysical profile: Saranda-Gjirokastra region.

Legend: as in Fig. 14.

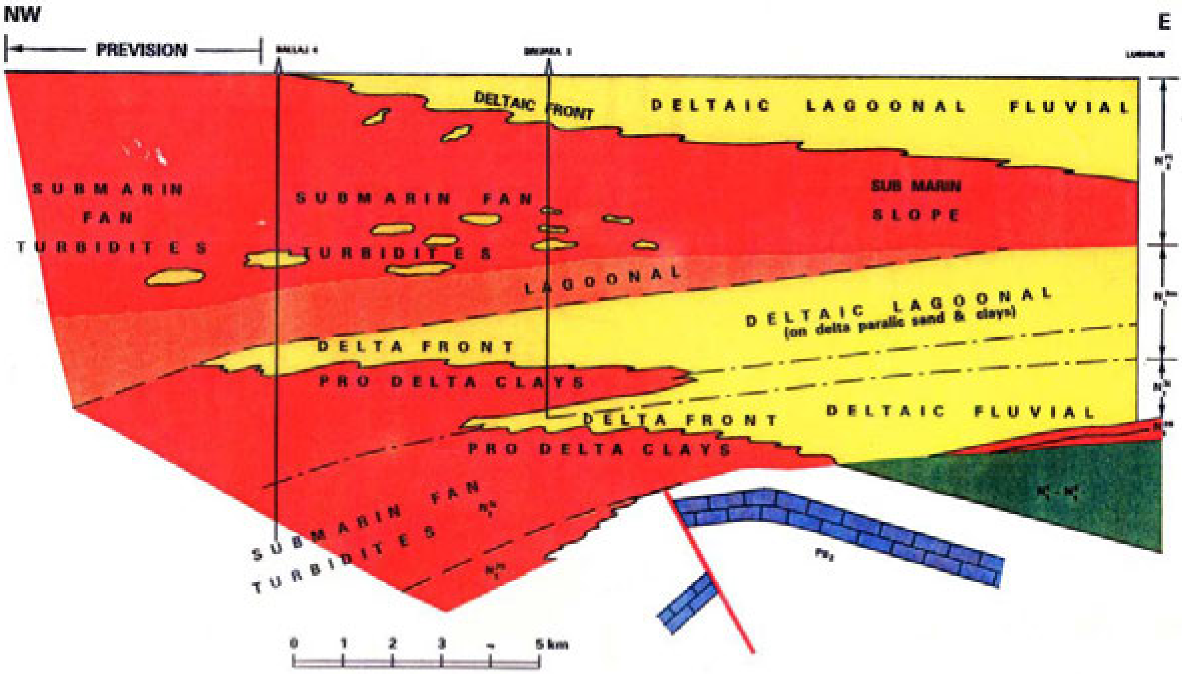


Fig. 24. Geological profile: Divjaka brachi anticline in Peri-Adriatic Depression.

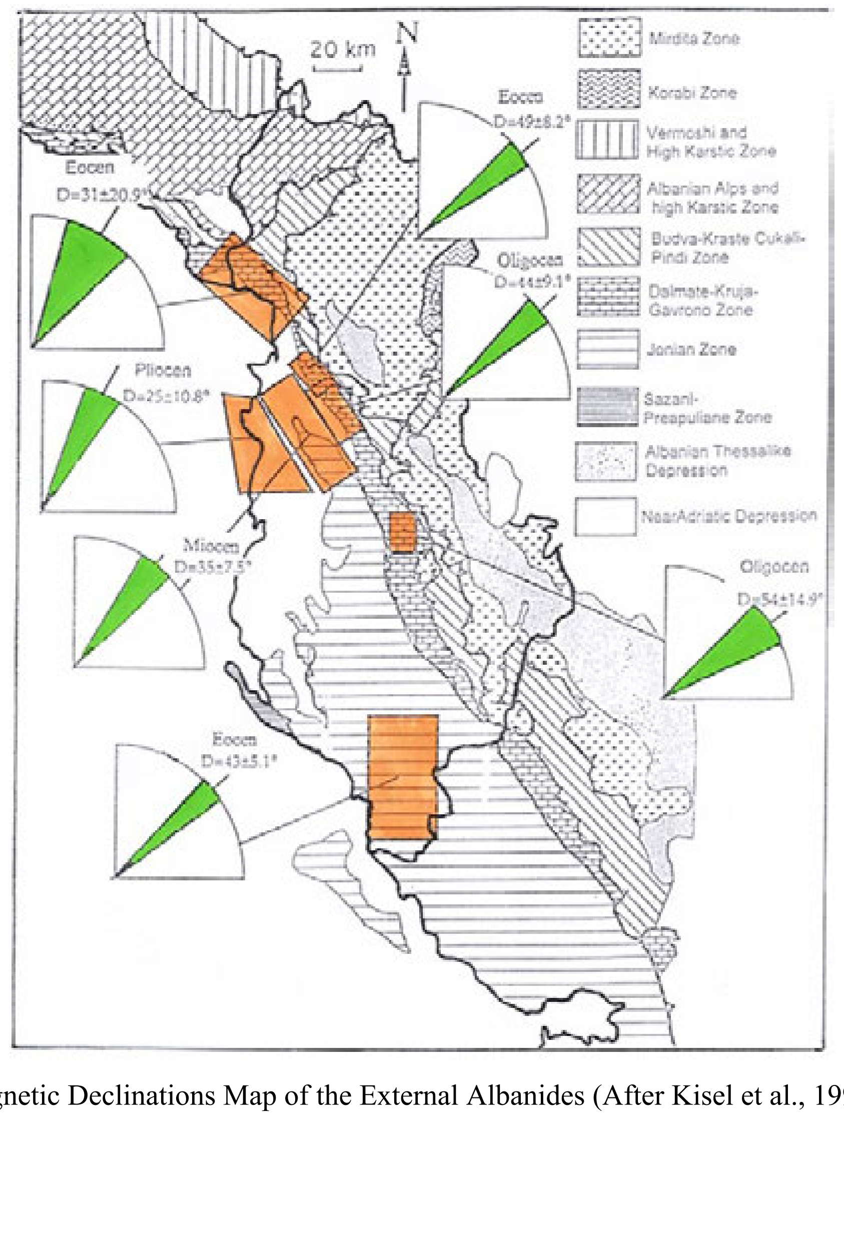


Fig. 25. Paleomagnetic Declinations Map of the External Albanides (After Kisel et al., 1994).

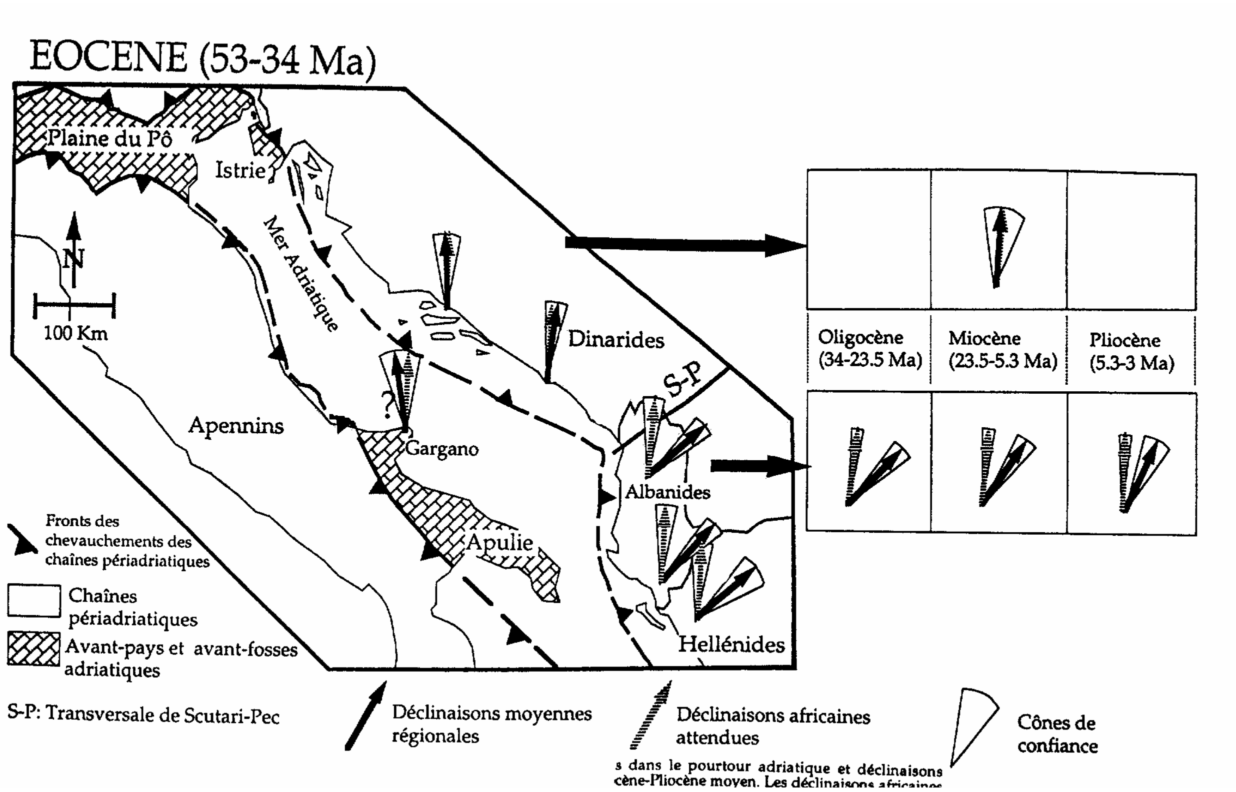


Fig. 26. Regional Paleomagnetic Declinations around Adriatic Sea and expected paleomagnetic declination for Africa during the Eocene-middle Pliocene period (After Speranza, 1995).

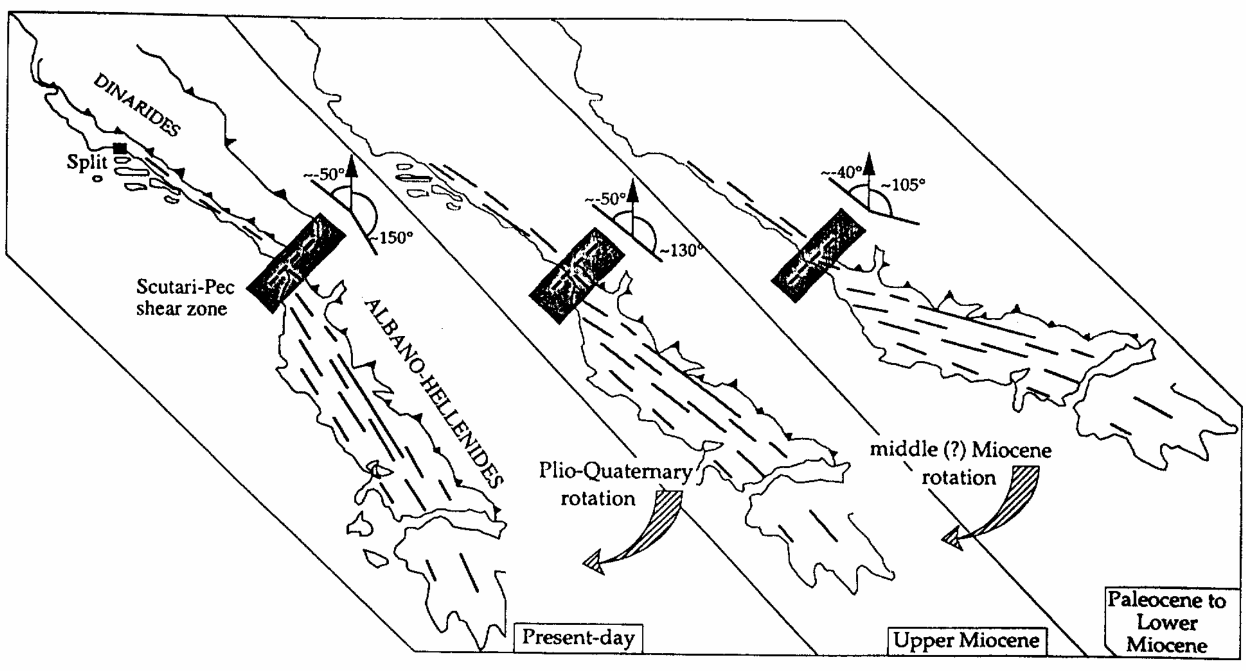


Fig. 27. Schematic evolution of the orientation of Albanides-Hellenides and Dinaride structures during the Cenozoic era, (After Speranza, 1995).

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"OUTLOOK ON PRINCIPLES FOR PROJECTING OF INTEGRATED AND CASCADE USE OF GEOTHERMAL ENERGY OF LOW ENTHALPY IN ALBANIA".

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Abstract

Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters are sulfate, sulfide, methane, and iodinate-bromide types. Thermal sources are located in three geothermal zones:

Kruja geothermal zone represents a zone with bigness geothermal resources. Kruja zone has a length of 180 km. Identified resources in carbonate reservoirs are $5.9x10^{8}$-$5.1x10^{9}$ GJ,

Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs.

Peshkopia gjeotermal zone at northeastern area of Albania. Several springs are located with disjunctive tectonics of the gypsum diapir.

The geothermal situation in Albania offers three directions for the exploitation of geothermal energy:

- **Firstly,** the uses of the heat flow of shallow geological section for heating and cooling of the buildings. Integrated exploitation and cascade direct use of the geothermal energy must realize by integrated scheme of geothermal energy, heat pumps and solar energy to fulfill.
- **Secondly**, thermal sources of low enthalpy are natural sources or wells in a wide territory of Albania. They represent the basis for a successful use of modern technologies for a *complex and cascade exploitation* of this energy, achieving an economical effectiveness:

1. SPA clinics for treatment of different diseases and hotels for ecotourism.
2. The hot water for heating and sanitary waters of the SPA and hotels, greenhouses and aquaculture installations.
3. From thermal waters it is possible to extract chemical microelements.

- **Thirdly**, the use of deep abandoned oil and gas wells as "Vertical Earth Heat Probe".

Actually in Albania the study of the possibilities of exploitation of the geothermal energy has begun. The aims of the project are to examine, demonstrate and disseminate the positive technical and financial aspects of transfer and utilization of innovative geothermal energy technologies in Albania.

1. INTRODUCTION

In Albania, rich in geothermal resources of low enthalpy and mineral waters, new technologies of direct use of geothermal energy are still untouched. Large numbers of geothermal energy of high and low enthalpy resources, a lot of mineral water sources and some CO_2 gas reservoirs represent the base for successfully application of modern technologies in Albania, to achieve economic effectively and success of complex exploitation.

Actuality, there are many geothermal, hydrogeological, hydrochemical, biological and medical investigations and studies of thermal and mineral water resources carried out in Albania. The results of the geothermal studies carried out in Albania are presented in maps and geothermal sections. Temperature maps have been drowning for different levels of up to 5000m depth. Geothermal gradient, heat flow density and geothermal resources maps have also been drawn. The natural springs with thermal waters and the geological structures with high water temperature have also been mapped. Generally, these investigations and studies are separated each from the other. Their information and data will serve for studies and evaluations in Albania regional scale. These studies and evaluations are necessary to well know in regional plane the thermal and mineral water resources potential and geothermal market of the Albania.

According to results of these new studies, the evaluation for the perspective level of the best areas in country will be necessary. After the evaluation is possible to start investments in these areas. Integrated exploitation and cascade direct use of the geothermal energy will realized by integrated scheme of geothermal energy, heat pumps and solar energy to fulfill. This scheme has an environmental benefit by using renewable energies (geothermal energy, solar energy), new technologies (heat pumps) and energy savings (cascade scheme). Cascade scheme should be used to fulfill the thermal energy demand for the selected area in order to get the maximum benefit from geothermal energy and the minimum energy supply from heat pumps: the promotion of energy savings will be in place.

Exploitation of geothermal energy will have a direct impact in the development of the regions, by increasing their per capita income and at the same time ameliorating the standard of living of the people. These investments will be profitable in a short period of time.

2. GEOTHERMAL ENERGY RESOURCES IN ALBANIA

2.1. Methodic

The results of the geothermal studies carried out in Albania are presented in maps and geothermal sections. Temperature maps have been drowning for different levels of up to 5000m depth (Frasheri A. et al. 1995, 1996, 2004). Geothermal gradient, heat flow density and geothermal resources maps have also been drawn. The natural springs with thermal waters and the geological structures with high water temperature have also been mapped (Frasheri A. 1992, Frasheri A. et al. 1995). The water basins with higher average temperature than that of yearly average in one of the regions has been studied as well. The study of the possibility of exploitation of abandoned deep oil wells as “Vertical Earth Heat Probes” has already begun.

2.2 Geothermal Features

The Albanides form an integral part of the southern branch of the Mediterranean Alpine orogen. They are subdivided in two zones: the Internal and the External Albanides. The geology of Albanides creates the premises for the research and exploitation of natural geothermal energetic resources.

The greatest heat flow density with a value of 42 $mW \cdot m^{-2}$ is found in the center of the Preadriatic Depression (Fig. 1). In the east of the ophiolitic belt heat flow density reaches values of up to 60 $mW \cdot m^{-2}$.

The temperature at a depth of 100m ranges 6.7 to 18.8°C, in average 16.4^{o}C (Fig. 2) and at a depth of 500m from 21 to 27.7°C.The temperature ranges up to 105.8°C at a depth of 6000m. In the central part of the Preadriatic Depression, there are many deep oil wells where the temperature reaches up to 68°C at a depth of 3000m (Fig. 3).

The geothermal gradient has the highest value about 18.7 $mK \cdot m^{-1}$ in the center of the Peri Adriatic Depression. Elsewhere the gradient is mostly 15 $mK \cdot m^{-1}$ (Fig. 4, 5). In the south of the country the geothermal gradient has low values 11.5-13 $mK \cdot m^{-1}$. Towards the northeastern and southeastern regions of Albania, over the ophiolitic belt, the geothermal gradient increases, reaching the value of 23.5 $mK \cdot m^{-1}$.

2.3. Geothermal Areas and Reservoirs

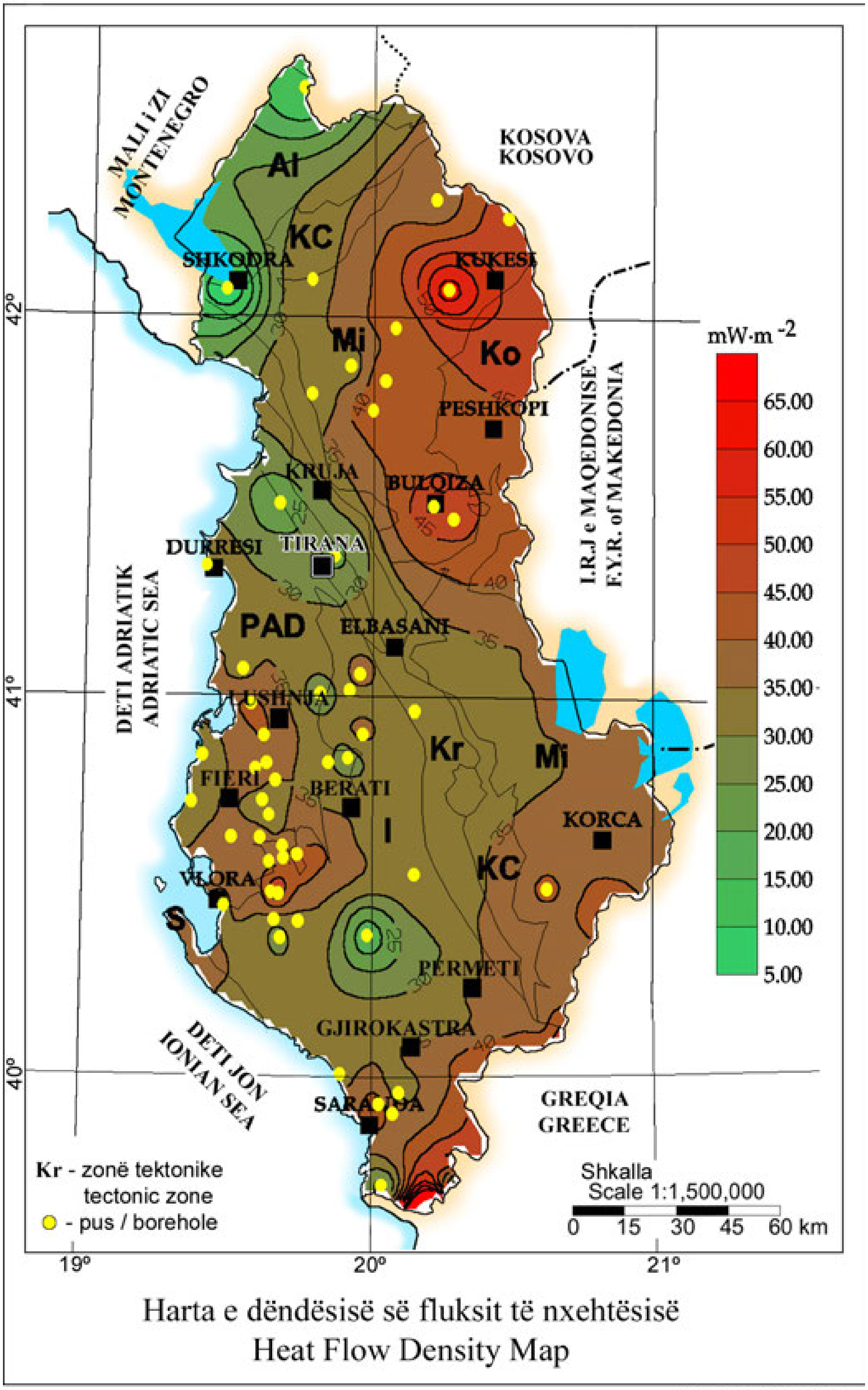
In Albania there are many thermal springs and wells of low enthalpy (Fig. 6, Tab. 1) (Frasheri A. et al. 1997, 2004) .

Tab. 1

Thermal water sources and wells in Albania

Type of the source	Location	Tempe-rature, (°C)	Salt, (mg/l)	Yeild, l/sec
Natural Spring	Llixha Elbasan, Peshkopi, Krane (Sarande), Langaric (Permet), Shupal (Tiranë), Sarandoporo (Leskovik), Postenan (Leskovik) Tërvoll (Gramsh), Mamurras (Tiranë).	21-60	0.3-26	10-40
Deep wells	Peri Adriatic Depression and in the Kruja tectonic zone	29.3-65.5	1-19.3	0.9-18

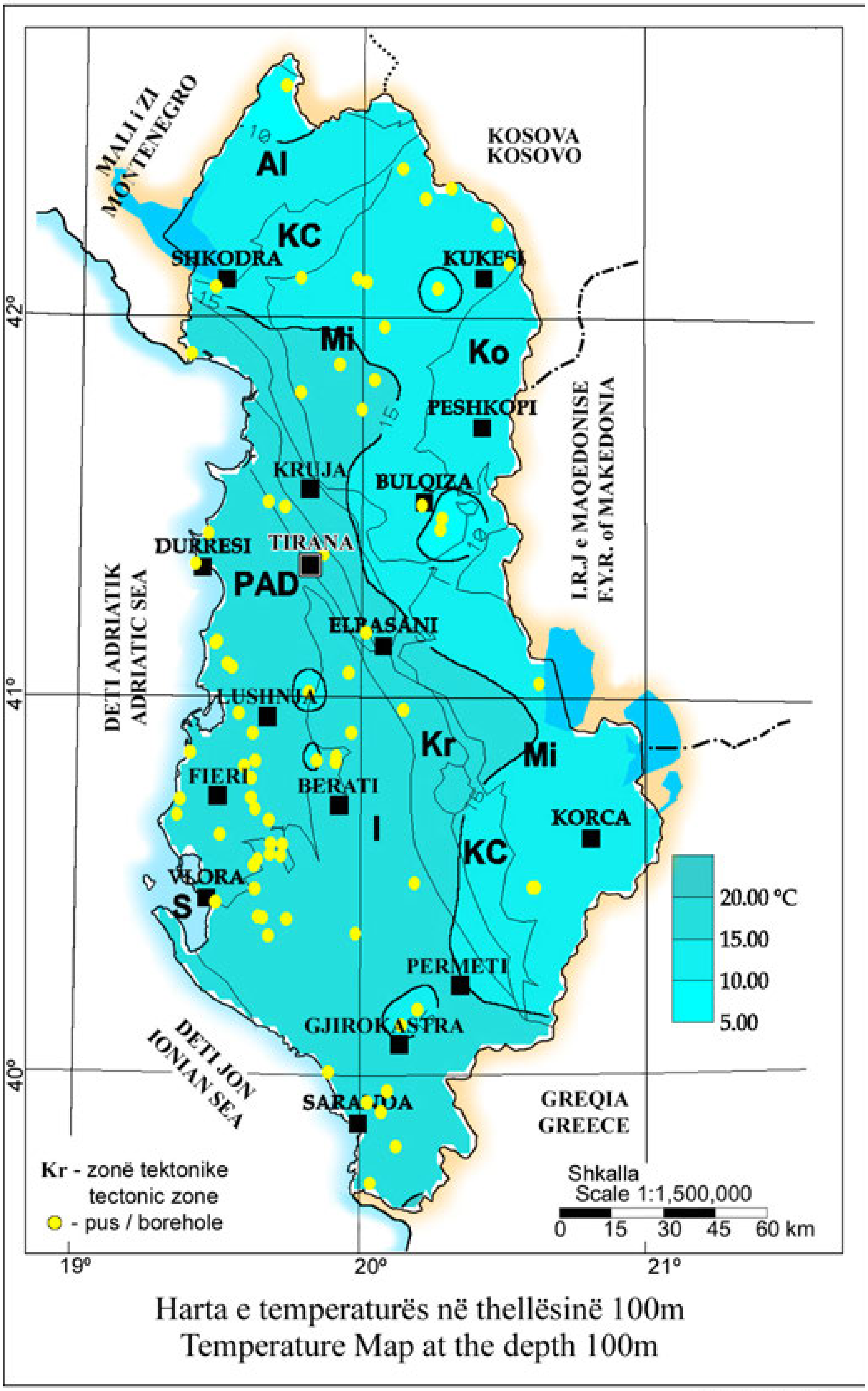
These thermal water springs and wells are mainly near zones of regional tectonic fractures. Generally the water circulates through carbonatic rocks of the structures and evaporitic beds at some kilometers of depth. The water of these springs contains salt, absorbed gas and organic matter. They are sulfide: methane, iodine-bromium and sulfate types. The waters come from different depth levels (800-3000 m) of limestone reservoirs and sandstone reservoirs. Thermal sources are located in three geothermal zones (Fig. 6):



Harta e dëndësisë së fluksit të nxehtësisë
Heat Flow Density Map

Fleta / Plate 16

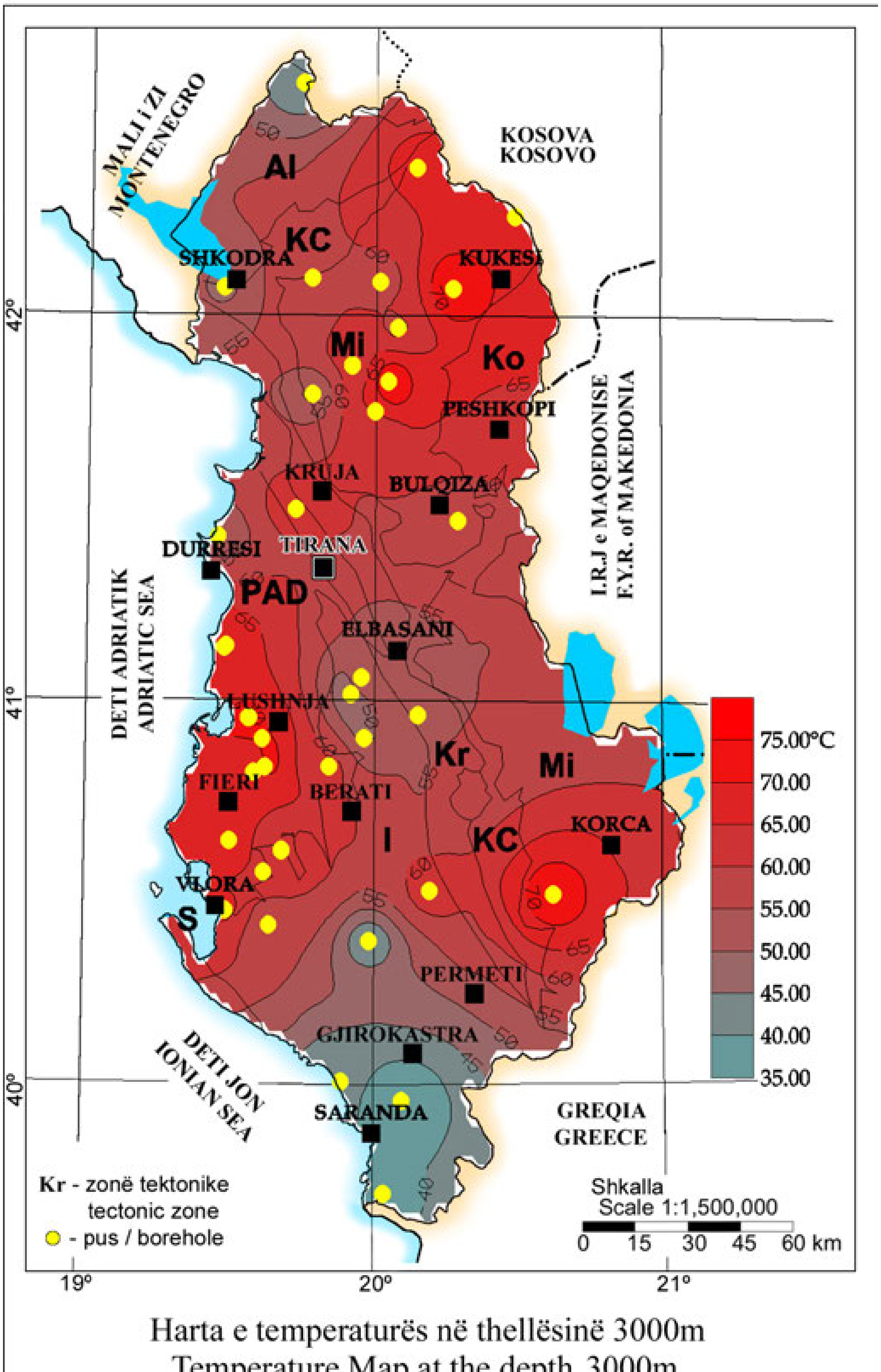
Fig. 1



Harta e temperaturës në thellësinë 100m
Temperature Map at the depth 100m

Fleta / Plate 7

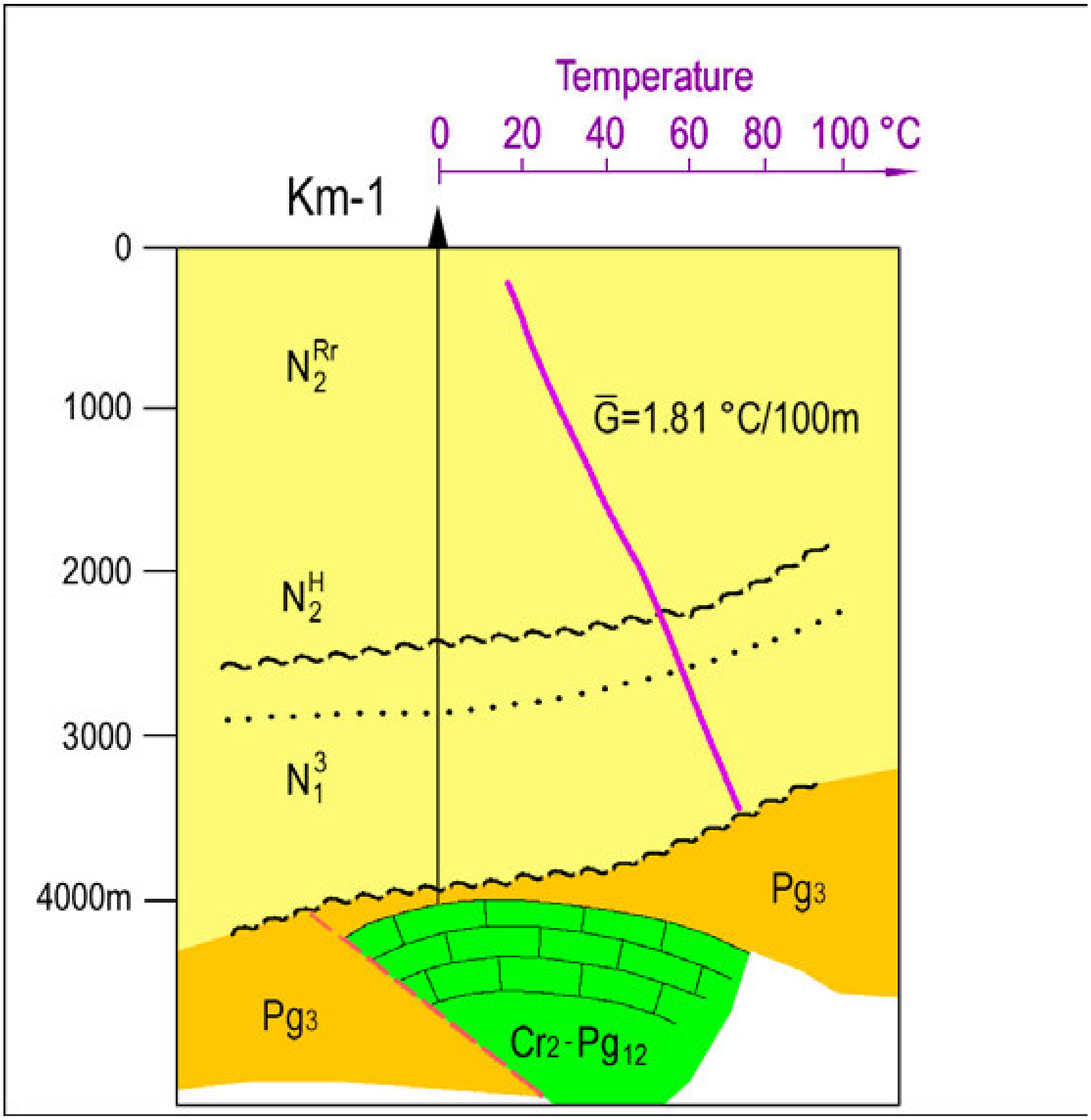
Fig. 2



Harta e temperaturës në thellësinë 3000m
Temperature Map at the depth 3000m

Fleta / Plate 12

Fig. 3


Temperature
0 20 40 60 80 100 °C
Km-1
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1000
2000
3000
4000m
N_2^{Rr}
$\bar{G}$=1.81 °C/100m
N_2^H
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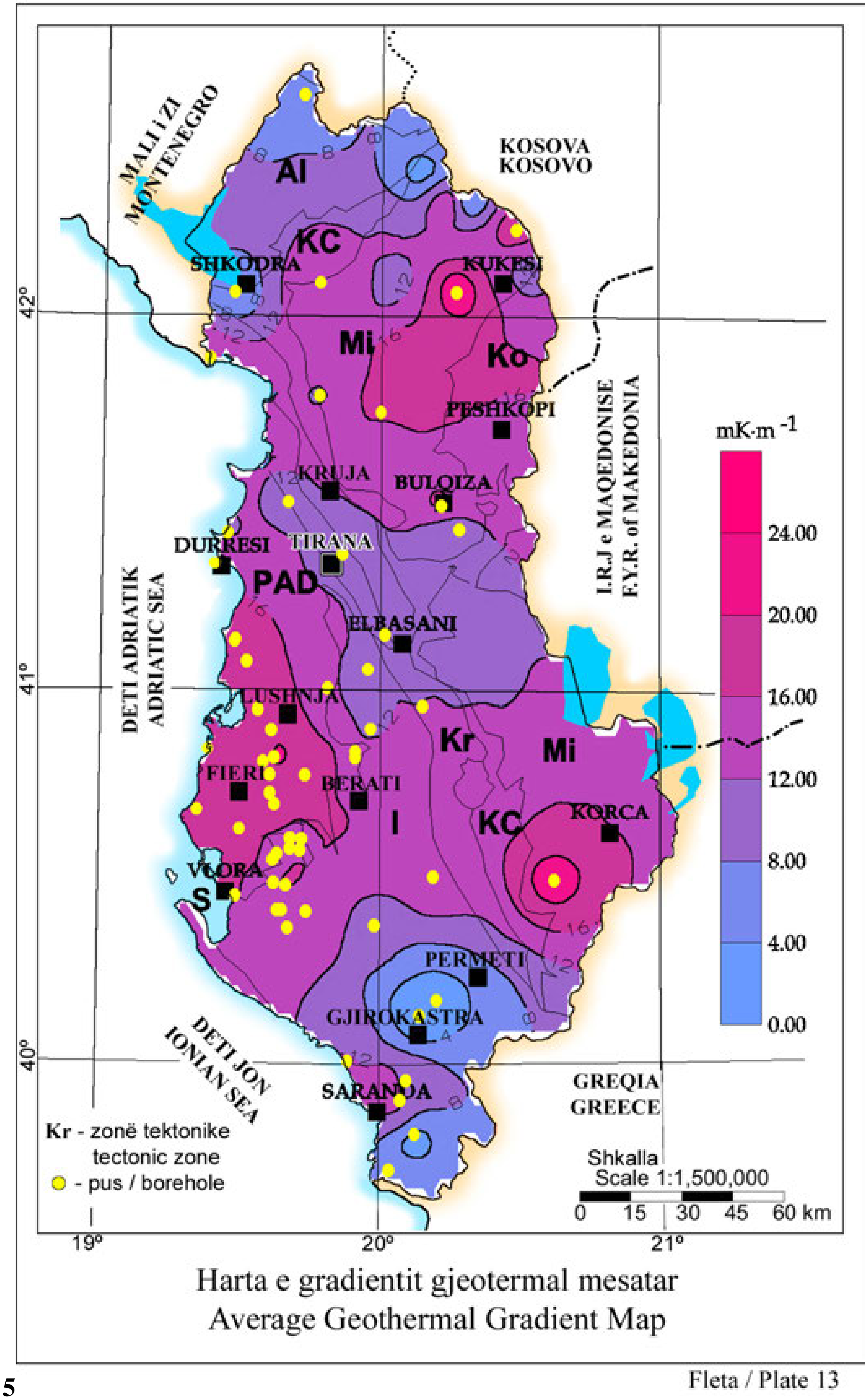
Pg_3
Pg_3
Cr_2-Pg_{12}

Fig. 4


MALI i ZI
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PESHKOPI
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DETI JON
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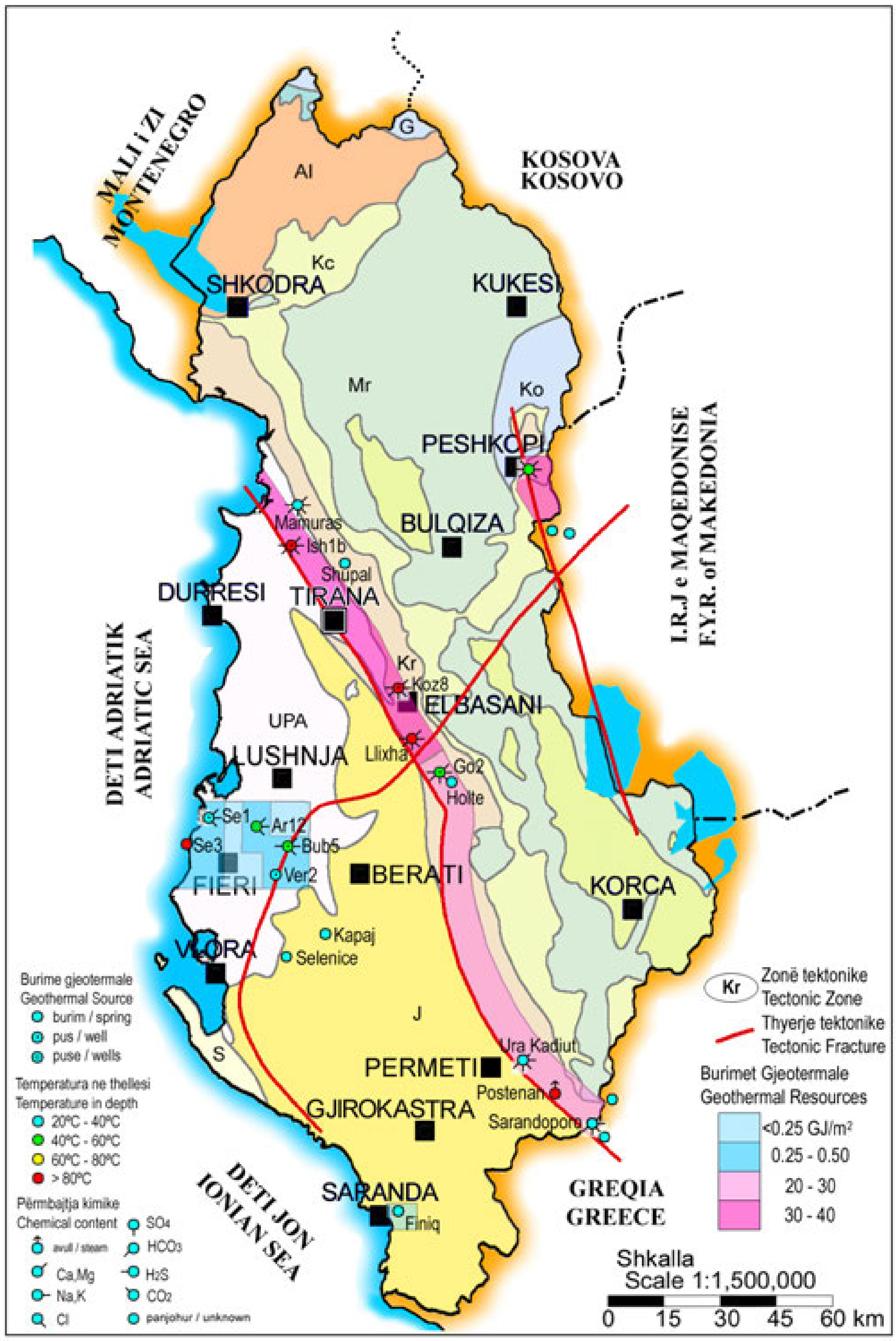
I.R.J e MAQEDONISE
F.Y.R. of MAKEDONIA
GREQIA
GREECE
mK·m -1
24.00
20.00
16.00
12.00
8.00
4.00
0.00
42°
41°
40°
19°
20°
21°
Kr - zonë tektonike
tectonic zone
- pus / borehole
Shkalla
Scale 1:1,500,000
0 15 30 45 60 km
Harta e gradientit gjeotermal mesatar
Average Geothermal Gradient Map
Fleta / Plate 13

Fig. 5



Harta tematike gjeotermale
Geothermal Thematic Map

Fig. 6

Fleta / Plate 17

Kruja geothermal zone represents a zone with bigness geothermal resources. Kruja zone has a length of 180 km. Identified resources in carbonate reservoirs are $5.9x10^{8}$-$5.1x10^{9}$ GJ,
Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs.
Peshkopia gjeotermal zone at northeastern area of Albania. Several springs are located with disjunctive tectonics of the gypsum diapir.

3. DIRECTIONS FOR THE EXPLOITATION OF GEOTHERMAL ENERGY OF LOW ENTHALPY IN ALBANIA

The geothermal situation of low enthalpy in Albania offers following directions for the exploitation of geothermal energy, which is unused until now. This exploitation will realized by integrated scheme of geothermal energy, heat pumps and solar energy, and cascade use of this energy (Frasheri A. 2000, Frasheri A. et al. 1997).

- **Firstly,** space heating and cooling using ground heat by the Borehole Heat Exchanger (BHE), in the shallow (about 100 m depth) boreholes.

- **Secondly**, thermal sources of low enthalpy and of maximal temperature up to 80°C. These are natural sources or wells in a wide territory of Albania, from the South near Albanian-Greek boundary to Northeast districts in Diber Region.

Thermal waters of springs and wells in Albania may be used in several ways:

1. Modern SPA clinics for treatment of different diseases and hotels, with thermal pools, for development of eco-tourism.

Such centers may attract a lot of clients not only from Albania, because not only the good curative properties of these waters but also because they are situated in nice places near sea side, mountains or Ohrid lake. In the present some SPA, with a primitive technology, worked in some geothermal springs and wells in Albania.

The oldest and important is **Elbasani Llixha SPA,** which located about 10 km south of Elbasani city and 61 km in south-east of Tirana, in the Central part of Albania. By national road communication, Llixha area is connected with Elbasani and Tirana. Only 10 km will be from the highway Durresi- Skopje- Sofia- Istanbul, which is projected for construction in the future and nominated as No. 8 European Corridor. This area may be frequented by a large number of people from different countries. These thermal springs from about 2000 years ago are known. According to historic data, in Elbasani Llixha thermal springs there has been a center near of the old road “Via Egnatia" that has passed from Durresi to Constantinople. Numer of the Albanian patients treated for rheumatism and various illnesses in Elbasani Lixha SPA in maximum are 7899 person/year. All seven groups of the springs in Llixha Elbasani and Kozani-8 well geothermal area will have the possibilities for modern complex exploitation. The beautiful landscape of Elbasani Lixha area will be not only for medical treatment but also as tourist place. This area located near of the very know Ohrid Lake pearl or mountains Gjinari, with their fantastic forests and nice climate. Ishmi 1/b geothermal well is located in beautiful Tirana field, near of Rinasi (Tirana) Airport, near of the Adriatic coastline and Kruja - Skendergeg Mountain.

Benja and Sarandaporo thermal water areas and Postenani steam springs are located near of the beautiful Vjosa River valley. Peshkopia geothermal springs area is located near of the Korrabi Mountain, higher mountain in Albania (2753m). The beautiful landscape of Vjosa valley, near Albanian-Greek border, and Peshkopia area near of the Debar region in Macedonia, will be not a thermal water bearing place for medical treatment but also as tourist place.

2. The hot water can be used also for heating of hotels, clinics and tourist centers, as well as for the preparation of sanitary hot water used there. Near these medical and tourist centers it is possible to built the greenhouses for flowers and vegetables, and aquaculture installations.

3. From thermal mineral waters it is possible to extract very useful chemical microelements as iodine, bromine, chlorine etc. and other natural salts, so necessary for preparation of creams for the treatment of many skin diseases as well as for beauty care products. From these waters it is possible to extract sulphidric and carbonic gas. It is possible to built installations for processing of mineral waters.

Consequently, the sources of low enthalpy geothermal energy in Albania, which are at the same time the sources of multi-element mineral waters, they represent the basis for a successful use of modern technologies for a <u>*complex and cascade exploitation*</u> of this energy, achieving a economical effectiveness. Such developments are useful also for the creation of new working places and improvement of the level of life for local communities near thermal sources.

- **Secondly,** the use of deep doublet abandoned oil and gas wells and single wells for geothermal energy, in the form of a "Vertical Earth Heat Probe". The geothermal gradient of the Albanian Sedimentary Basin has average values of about 18.7 $mK \cdot m^{-1}$. At 2 000 m depth the temperature reaches a value of about 48°C. In these single abandoned wells a closed circuit water system can be installed. Near of these wells, can be build greenhouses.

Actually in Albania the study of the possibilities of exploitation of the geothermal energy has begun. Based on the above analysis, for the best area selected, a Feasibility Study will be performed to analyze three components: energy supply, environmental impact and financial aspects, and to suggest the best solution of the innovative geothermal energy utilization technology applications in that area.

4. ALBANIAN GEOTHERMAL ENERGY MARKET

Objectives of market study:

- Evaluation of present status of geothermal development in Europe, particularly in Balkan countries, regarding promotion activities, results, application, barriers for market penetration, legal and financial framework, etc.
- Comparison of present status between the different Albanian regions.
- Identification of the attitude and feelings (awareness, knowledge, preference, etc.) for the target groups towards geothermal energy.

• Identification of the attitude and feelings of the target groups towards environmental aspects of geothermal energy.
• Evaluation of the outcome of promotion methods adopted by EU and national institutions.
• Formulation of proposals for effective promotion strategies for geothermal energy in Albania.

Amend above proposals in order to transform them to effective promotion strategies for geothermal technologies in Albania.

4.1. Space heating and cooling

The energy crisis prevailing in the Albania, the increased demand in energy for heating and cooling of premises. Actually, the electric energy consummation for heating is 1 375 GWh/year, or 23.8 % of the total electric energy production in Albania (Fig. 7) (National Agency of Energy, Tirana, 2003). The situation becomes more problematic because the use of natural gas for heating emits large quantities of CO_2 in the atmosphere.

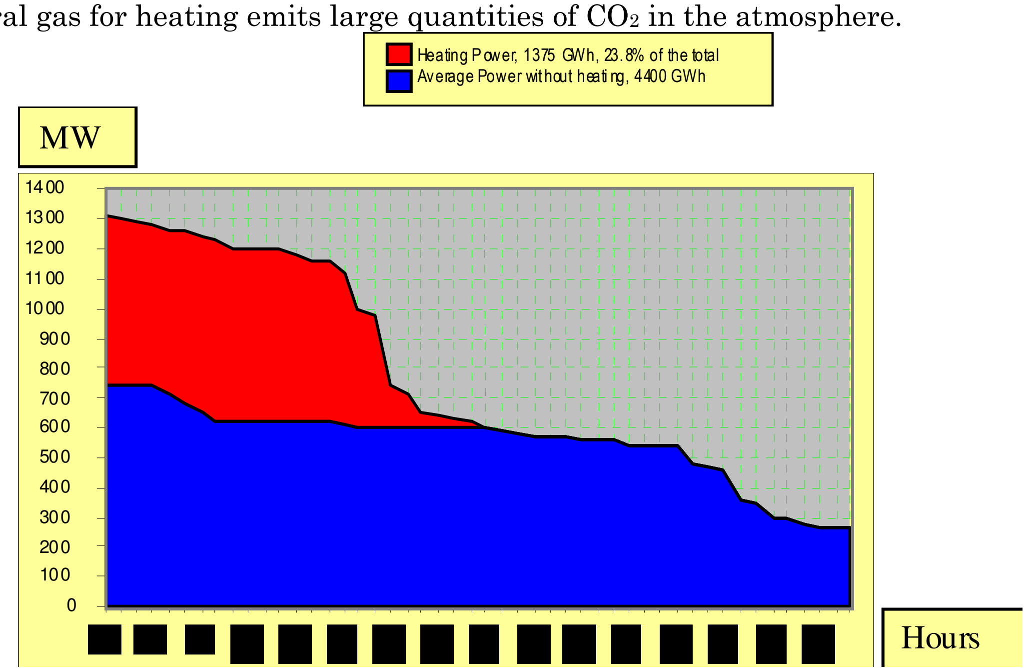


Fig. 7. Consummation for heating is 1 375 GWh/year, or 23.8 % of the total electric energy production in Albania

Direct use of the ground heat by Borehole heat Exchanger-Geothermal Heat Pump represents a modern system for space heating and cooling. Two types of shallow heat sources exist: ground heat and underground waters heat. Consequently two kind of technology is possible to applied:

Firstly, ground-source and Borehole heat Exchanger-Geothermal Heat Pump or ground-couplet (closed loop) (Fig. 8),

Secondly: underground water system – Geothermal Heat Pump (open loop). Ground coupling is used where insufficient well water is available or where quality of the well water is a problem.

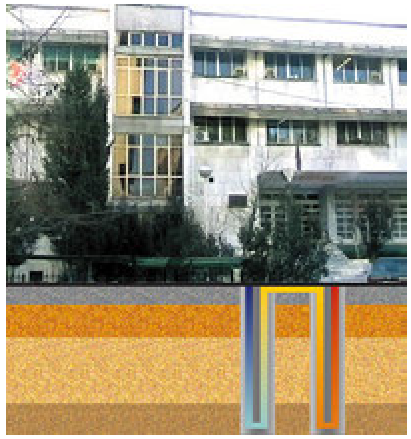


Fig. 8. Borehole Heat Exchanger-Geothermal Heat Pump System

In order to make use of this renewable geothermal energy and environmental friendly ground heat for space heating and cooling in Albania, we have introduced the idea of building a demonstrative installation for heating and cooling purposes in Tirana (Frasheri et al. 2003). It will contribute in solving the problematic issue of heating and cooling of premises in Albania.

Heat quantity, temperature at Earth surface, and geothermal gradient in shallow geological section, are conditioned by geographical location, geomorphological conditions, ground and bedrocks lithology, specific heat and humidity, seson and weather. According to the multy annual meteorological surveys result that in average is 140,000 calory.cm^{-2} heat from solar radiation of the ground during the summer at the plane areas of the Albania. Heat quantity reaches 120,000 calory.cm^{-2} at noertheaster mountains regions [Gjoka L., 1990].

There are some particularities in the distribution of the temperature at the depth 100m (Fig. 2):

Temperature in subsurface ground at littoral area:
Minimal temperature is 16.60 ^{o}C
Maximal temperature is 18.80 ^{o}C
Average temperature is 17.80 ^{o}C

Temperature in subsurface ground at western plane-hilly area:
Minimal temperature is 17.15 ^{o}C
Maximal Temperature is 18.41 ^{o}C
Average Temperature is 18.0 ^{o}C

Temperature in subsurface ground at hilly-mountains regions:
Minimal temperature is 6.70 ^{o}C
Maximal temperature is 18.60 ^{o}C
Average temperature is 14.75 ^{o}C

In plane area of Albania, example in the Tirana field (Rinasi), the temperature is 15.5 ^{o}C, up to logging depth 31 m, in the Quaternary deposits (Fig. 9) (Frasheri et al. 2003).

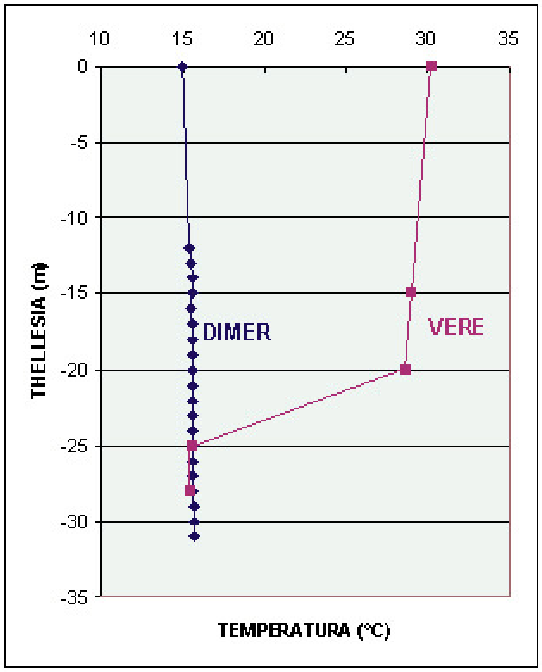


Fig. 9. Ground temperature at Tirana Area

According to the analyse of the geothermal regime of the shallow geological section is concluded that is possible to use the ground heat for the space heating and cooling, applied modern Borehole Heat exchanger – geothermal Heat Pump.

Ground geothermal energy has heated the underground water reservoir (Fig. 10). In Tirana underground water basin are following temperatures:

Water temperature of the Quaternary gravel layer is 14-15 ^{o}C,

Water temperature of the Quaternary sandstone layers is 15-16^{o}C

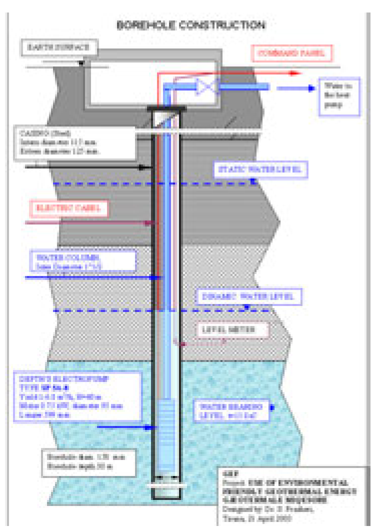


Fig. 10 . Borehole in underground water basin in Tirana region

Consequently, concluded that water of the Tirana underground basin can be a heat source for the geothermal pumps.

COST FOR HEATING SYSTEMS

Total surfaces of 3 floors 610 m^2**,** 20 rooms, 3 halls, 7 restrooms.

Heating: by heat conveying-radiators

Heating Capacity 68.5 KW

Installation cost	**Total,** (in Euro)	**Specific,** (in Euro/m2)
- Borehole-Geothermal Heat Pump	43.000	71,66
- Gas boiler	21.000	35,00
- Air-Air conditioners, type “General”	15.600	26,00

Yearly of the electrical energy or gas consumption and cost:

a) Borehole-Geothermal Heat Pump	42.447 KW	4.295 Euro
b) Gas boiler	15.654 Liter gas	14.089
c) Air-Air conditioners	119.340 KW	11.982
d) Electrical heat conveying-radiators	175.500 KW	17.480

Yearly cost of heating energy:	**First year** In Euro/KW	in - Euro/m^2	**Second year** in - Euro/KW	in - Euro/m^2
Borehole-Geothermal Heat Pump	691,4	77,5	62,7	4,07
Gas boiler	513,2	57,5	205,9	23.09
Air-Air conditioners	403,2	45,2	175,2	19,64

Payback period for installation of the “Borehole-Geothermal Heat Pump” System investment:

2.2 years, only by yearly savings of the expenses for boiler gas
2 years, only by yearly savings of the expenses for electrical energy for conditioners

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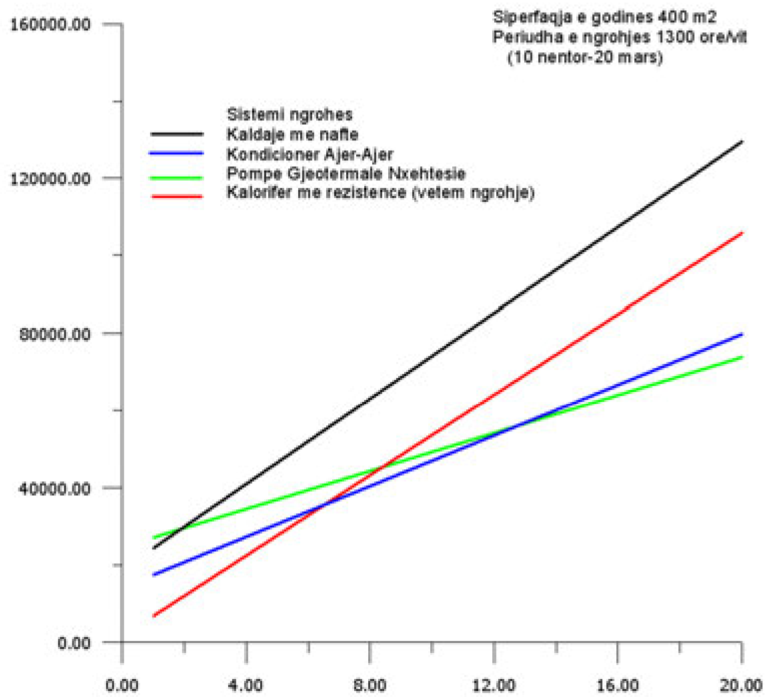

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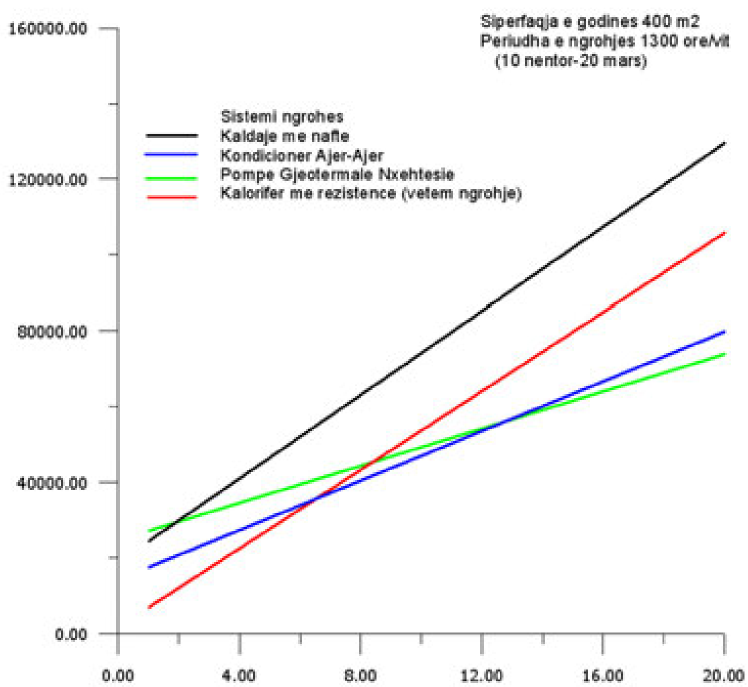


4.2. Consumers for geothermal energy & thermal water (heat, spa, cooling, power production, drinking water, aquaculture, agriculture)

At the present, some spa, with a primitive technology, worked in geothermal springs and wells in Albania: Lixha Elbasani (Photo 7), Bilaj Balneological Center (Ishmi 1/b well) (Photo 8), Peshkopia (Diber district) SPA (Photo 9), Sarandaporo (Leskovik Disrict) SPA, Langarica-Ura Kadiut (Permeti District) SPA.

The oldest and important is **Elbasani Llixha SPA,** which located about 10 km south of Elbasani city and 61 km in southeast of Tirana, in the Central part of Albania. By national road communication, Llixha area is connected with Elbasani and Tirana. Only 10 km will be from the highway Durresi- Skopje- Sofia- Istanbul, which is projected for construction in the future and nominated as No. 8 European Corridor. The proximity with highways create great possibilities for Elbasani Lixha SPA to be a nice place. This area may be frequented by a large number of people from different Balkan countries, Italy, UK, Germany, Ostrich, France, Low Countries, and by Albanians from Albania, Macedonia and Kosovo as well. These thermal springs from about 2000 are know years ago. According to historic data, in Elbasani Llixha thermal springs there has been an inn, near of the old road "Via Egnatia" that has passed from Durresi to Constantinople.

Llixha Elbasani Geothermal Springs Area

There are seven spring groups that extend like a belt with 320^{o} azimuth. Surface water temperature is about 60^{o}C and yield in total 15 l/sec. Springs have constant hot water yield and temperature for a long period of time. These data are evidence of a stable thermo-hydrodinamic reservoir regime.

Before the Second World War, in one from the springs ("Nosi spring") has been constructed " PARK-NOSI" SPA (***), with 166 beds, for medical treatment of various diseases, generally

rheumatic. The “NOSI” SPA functioned during a period of time more than 60 years and for the present is private property. Land with surface of 20 000 m^2, hotel and restaurant are owned by PARK NOSI Sh.p.k.. Particularly reconstructed hotel after the privatization actually is in work. Near this property there is located a public hotel, with 180 beds, almost in destruction state, but which may be reconstruct.

Park Hotel SPA at Llixha Elbasani Geothermal Springs

Albanian patients treated for rheumatism and various illnesses in Elbasani Lixha SPA are:

in 1990	7899 persons (Public two hotels)
1994	3603 persons (after the privatization, only in Park NOSI Hotel)
2002	1800 persons, generally retained seek people (only in Park NOSI Hotel. In Elbasani spa actually are three hotels).

The price in PARK-Nosi SPA, for day’s treatment (hotel, meal and treatment) in SPA, for Albanian patient, in actual economical situation, is 10 USD/day, (VAT Is included in the price). This is a more chipper price compared with hotels in Elbasani city, regarding accommodation and breakfast only. From 40 to 240 USD per dayare actually the price in Tirana hotels. About this price, it is necessary to expose the following: In the future, the increase of price for daily treatment of the patient in spa, will be increase also the profit, according to:

Firstly, improvement of the medical treatment, of the accommodation and food conditions in the spa. SPA will be visited by Albanian or foreign tourists, not only olld and retired perople, like at the present.

Secondly, from foreign and Albanian patients, the spa frequenting demand will be increase, according to new situation of the supply and demand.

Thirdly, the life level of Albanian people will be higher. Spa will be frequenting by Albanians from Macedonia and Kosovo, which have more high economic level.

Land price in Elbasani region, in 1996, has been 5-7 USD/m^2.

Actually, is not a law for thermal waters in Albania, last year has been prepared the draft of the law. The PARK NOSI Sh.p.k. Llixha Elbasani, is using thermal spring as ex-owner of spa before the Second World War. SPA in Ishmi well area and Sarandaporo spa have been private in 1993 and 1998 respectively.

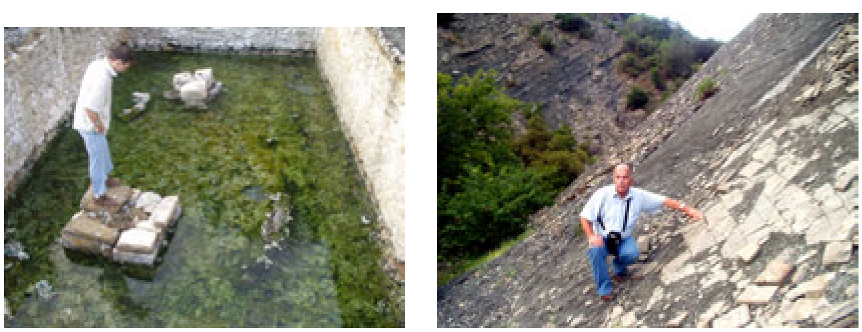
All seven groups of the springs in Llixha Elbasani and Kozani-8 well geothermal area will have the possibilities for modern complex exploitation. The beautiful landscape of Elbasani Lixha area will be not only for medical treatment but also as tourist place. This area located near of the very know Ohrid Lake pearl or mountains Gjinari, with their fantastic forests and nice climate. Ishmi 1/b geothermal well is located in beautiful Tirana field, near of "Mother Theresa" Rinasi (Tirana) Airport, near of the Adriatic coastline and Kruja - Skendergeg Mountain. There are all the possibilities for the echo-tourism development: thermal water, Ishmi beach at the Adreatic Sea , and mountain's area.

Benja and Sarandaporo thermal water areas and Postenani steam springs are located near of the beautiful Vjosa River valley. Peshkopia geothermal springs area is located near of the Korrabi Mountain, higher mountain in Albania (2753m). The beautiful landscape of Vjosa valley, near Albanian-Greek border, and Peshkopia area near of the Debar region in Macedonia, will be not a thermal water bearing place for medical treatment but also as tourist place.

Benja Geothermal Springs Area

Postenani Steam Springs Area

7



Sarandaporo Geothermal Springs Area

Geological risk, financial possibilities to cover geological risk

No geological and financial risk for the exploitation of thermal water of geothermal springs and wells in Albania.

Traffic connections: roads, railways, navigation, and possibilities for transport of heavy goods

The **Ishmi-1/b well** is located in Ishmi area and represents the northernmost geothermal well of the Kruja geothermal area. It is located in 20 kilometers NW of Tirana (near of "Mother Theresa" Tirana Airport). By national road communication, Ishmi 1/b well is connected with Tirana, Tirana Airport, Durresi and Shkodra cities.

Kozani-8 well is located 35 kilometers southeast of Tirana, on hill's area. Well connected by 1.7 km road with Tirana-Elbasani national road, and hightway "Corridor 8" Durresi-Elbasan-Skopje. One km from Kozani 8 well located Saint George Vladimir Monastery.

Elbasani Llixha SPA is located about 12 km south of Elbasani city and 61 km in south-east of Tirana, in the Central part of Albania. By national road communication, Llixha area is connected with Elbasani and Tirana. Only 10 km will be from the highway Durresi- Skopje- Sofia- Istanbul, which is projected for construction in the future and nominated as No. 8 European Corridor. These thermal springs from about 2000 are known years ago. According to historic data, in Elbasani Llixha thermal springs there has been an inn, near of the old road “Via Egnatia" that has passed from Durresi to Constantinople.

Peshkopia geothermal springs are connected with Tirana by national road (182 km).

Peshkopia Geothermal Srings Area

Peshkopia SPA

Benja-Langarica, Postenani and Sarandaporo geothermal springs areas are located near of the national road Tirana-Permeti (about 217 km)-Konistza (Greece).

5. THE AIMS AND OBJECTIVES OF THE PROJECT FOR DIRECT USE OF THERMAL WATERS OF LOW ENTHALPY

5.1. The aims of the project

To examine, demonstrate and disseminate the positive technical and financial aspects of transfer and utilization of innovative geothermal energy technologies in Albania, which will have a direct impact in the development of the regions by increasing their per capita income and at the same time ameliorating the standard of living of the people.

This development will be achieved in parallel with the reduction of any negative environmental effect, which would have followed this type of development if older geothermal energy technology or even conventional sources of energy were to be utilized. Significant financial, social and technical benefits will arise from the promotion and final application of the results of this project.

5.2. Objectives:

Integrated exploitation and cascade direct use of the geothermal energy has projected.

The objectives of the project:

5.1. **Geothermal energy and mineral water resources evaluation** of country

5.2. **In-situ detailed investigation** of the pre-selected zones with high energy potential & consumers geothermal source, where will installed demonstrative unit.

Among others this task will be concerned with:

-Intentions of users-thermal load inspections
-Initial energy balance analyses
-Thermal characteristics of individual users
-Technical geothermal data collection
-Examination of existing technology

It is necessary to select the thermal applications, which correspond to the local needs. The following will be defined:

a) In situ consideration of geothermal physical-chemical parameters and potential
b) Thermal load demands for space heating for each end-user of geothermal sources:

- Dwellings,
- Geothermal SPA,
- Greenhouses,
- Geothermal pools, etc.,

-. Aquaculture,
- Mineral waters production
- Extraction of the micro-elements and natural salts

b) Energy balance between different end-users,
c) Technologies to be applied
d) Preliminary design of the geothermal energy exploitation system
e) Definition of thermal demands
i) Energy conservation, and
k) Economic evaluation of thermal energy (space heating and hot water production installation cost, life cycle, energy product cost, pay back period). This evaluation will be based on actual market prices for equipment, construction etc.

Based on the above analysis, for the best area selected, a feasibility study will be performed to analyze three components: energy supply, environmental impact and financial aspects, and to suggest the best solution of the innovative geothermal energy utilization technology applications in that area.

5.3. **Environmental protection and preserving** level will be improved, to well assist the echo-system protection of thermal and mineral water source areas.

Among other subjects this phase will focus mainly on:

-Examination of the nature of the geothermal fluid
-Environmental impact of the geothermal fluids during their utilization and disposition
- Selection of the most acceptable environmentally methods for the disposal of the geothermal fluids

5.4. **The concrete detailed design** for the implementation phase of the Project will be prepared.

Task 1. Demonstrative units (pilot plants) will be constructed, monitored and finally demonstrated. These demonstrative units will assist in the promotion of the new innovative technology application facilitating in parallel the transfer of this innovative technology to end users as well as industrial production.

The proposed schemes represent an integrated scheme and cascade scheme for exploitation of geothermal energy. This exploitation will realize by integrated scheme of geothermal energy, heat pumps and solar energy to fulfil. This scheme has an environmental benefit by using renewable energies (geothermal energy, solar energy), new technologies (heat pumps) and energy savings (cascade scheme).

Cascade scheme should be used to fulfil the thermal energy demand for the selected area in order to get the maximum benefit from geothermal energy and the minimum energy supply from heat pumps: the promotion of energy savings will be in place.

These demonstrative units will make researcher and scientists aware, on-site, of specific plant operational problems, new technology implementation problems and finally assist to their in situ solution.

These pilot demonstrative units will help potential users overcome psychological barriers towards the utilization of new innovative technologies for direct application.

Task 2: A promotion and tourist agency will be organized. This agency will prepare the reclaims and booking of the rooms for Albanian and foreign patients.

6. APPLICATION AND TRANSFER TECHNOLOGY FOR A COMPLEX AND CASCADE EXPLOITATION OF GEOTHERMAL WATERS ENERGY

6.1. **Construction of thermal supply installations**:

1. Installation of pipe – distribution system
2. Heat exchanger
2. Distributors
3. Control Room-Monitoring.

6.2. **Construction of the experimental units** for exploitation of the geothermal energy:

1. Building of spa, with 30-40 beds, for the medical treatment (gynecological and rheumatic diseases),
2. Construction of heating installation in the buildings
3. Construction of the greenhouse for the flower.
4. Construction of the greenhouse for the legumes.
5. Construction of thermal pool for tourists, wardrobe and bar.
6. Installation of equipment for extraction microelements and natural salts.

Feasibility Study

Technical and financial feasibility study for innovative geothermal energy utilization technology applications. Market penetration of geothermal energy.

Economic evaluation should include:

- First investments for the proposed schemes (integrated scheme, cascade scheme);
- Evaluation of thermal energy (space heating and hot water production) unit cost produced by integrated scheme: geothermal energy, heat pumps and solar energy;
- Evaluation of benefits (in financial terms) through comparison with the classical scheme of the proposed integrated and cascades scheme;
- Other benefits will be assessed for example the environmental benefit by using renewable energies (geothermal energy, solar energy), new technologies (heat pumps) and energy savings (cascade scheme).

Among others and for one of the two application cases this phase will be examine:

- Preliminary consideration for each case
- Definition of the main parameters affecting each system
- Analysis of the effect of the different parameters
- Selection of the "basic" application cases/techniques

- Design of the system
- Selection of alternative cases
- Final technical conclusions

Based on the above analysis, for the best area selected, a Feasibility Study will be performed to analyze three components: energy supply, environmental impact and financial aspects, and to suggest the best solution of the innovative geothermal energy utilization technology applications in that area.

7. PRELIMINARY COST FOR THE INVESTMENT

Cost estimation is carried out only for the first phases, to realize investment step by step:

No	Object	Cost, in USD
1	Reconstruction of heating and thermal baths	50 000
2	Construction of two thermal water unit equipment's	80 000
	Construction of green houses, 2 * surface 3 000 m^2	240 000
4	Construction of new SPA Clinic and for new hotel building), (****)	2 200 000
5	Feasibility study and project idea	53 000
9	Other Expenditures	20 000
10	Overhead rate TOTAL exc. VAT	15 000 2 418 000

8. ECONOMICAL-FINANCIAL EVALUATIONS

HOTEL-SPA, First Phase: 25 bed rooms, 40 beds.
Currency: USD Inflation rate: 3.5%

Table 1

Economic bases	Years				
	1st	2nd	3rd	4th	5th
1. Number of rooms (1)	25	25	25	25	25
2. Number of beds	40	40	40	40	40
3. Days of operation	280	280	280	290	290
4. Food&beverages-facilities	280	280	280	290	290
5. Guest structure and room price	100%	100%	100%	100%	100%
6. Average room occupancy	72	74	75	75	75
7. Average room price	50	50	55	55	60

1) Hotel has 15 doubles rooms and 10 single rooms
   Rata: Single room 50 USD; Double room 70 USD (Include VAT) (Present room's rate in *** Hotels in Tirana)

Supplementary facilities:

1. Outdoor-indoor thermal & swimming pool
2. Ball sports (tennis, volleyball, basketball)
3. Recreation (sauna, Turkish bath, solarium)
4. Fitness Center with aerobic
5. Restaurant, bar

6. Meeting room
7. Others (rent a car, coiffeur, boutiques)

9. APPLICATION AND TRANSFER TECHNOLOGY FOR A COMPLEX AND CASCADE EXPLOITATION OF GEOTHERMAL WATER ENERGY

9.1. Construction of thermal supply installations:

- Installation of pipe – distribution system
- Heat exchanger
- Distributors
- Control Room-Monitoring.

9.2. Construction of the experimental units for exploitation of the geothermal energy:

- Building of SPA, with 30-40 beds, for the medical treatment (gynecological and rheumatic diseases),
- Construction of heating installation in the buildings
- Construction of the greenhouse for the flower.
- Construction of the greenhouse for the legumes.
- Construction of thermal pool for tourists, wardrobe and bar.
- Installation of equipment for extraction microelements and natural salts.

9.3. Feasibility Study

Technical and financial feasibility study for innovative geothermal energy utilization technology applications. Market penetration of geothermal energy.

Economic evaluation should include:

- First investments for the proposed schemes (integrated scheme, cascade scheme);

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- Analysis of the effect of the different parameters
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9	Other Expenditures	20 000
10	Overhead rate TOTAL exc. VAT	15 000 2 418 000

11. ECONOMICAL-FINANCIAL EVALUATIONS

HOTEL-SPA, First Phase: 25 bed rooms, 40 beds.
Currency: USD Inflation rate: 3.5%

Table 1

Economic bases	Years				
	1st	2nd	3rd	4th	5th
8. Number of rooms (1)	25	25	25	25	25
9. Number of beds	40	40	40	40	40
10. Days of operation	280	280	280	290	290
11. Food&beverages-facilities	280	280	280	290	290
12. Guest structure and room price					
13. Average room occupancy	100%	100%	100%	100%	100%
14. Average room price					
	72	74	75	75	75
	50	50	55	55	60

2) Hotel has 15 doubles rooms and 10 single rooms
   Rata: Single room 50 USD; Double room 70 USD (Include VAT) (Present room's rate in *** Hotels in Tirana)

Supplementary facilities:

- Outdoor-indoor thermal & swimming pool
- Ball sports (tennis, volleyball, basketball)
- Recreation (sauna, Turkish bath, solarium)

- Fitness Center with aerobic
- Restaurant, bar
- Meeting room
- Others (rent a car, coiffeur, boutiques)

FINANCIAL BASES

Table 2

Proceeds	%	Years				
		1st	2nd	3rd	4th	5th
1. **Room Rental**	71					
(without breakfast)						
number of rooms		25	25	25	25	25
*day of operation		280	280	280	290	290
=max. room overnight		7 000	7 000	7 000	7 250	7 250
*average room occupancy				75%	75%	75%
=number of room overnight		72%	74%	5 250	5 438	5438
*average room price		5 040	5 180	55	55	60
=**arrangement** (without		50	50	288 750	299 090	326 280
f&b)		252 000	259 000			
2.**Food&beverage**	26					
a) Full Pension		100%	100%	100%	100%	100%
Number of consumptions		7 056	7 252	7 350	7 612	7 612
*Proceeds/guest		10	10	11	11	12
=full pension		70 560	72 520	80 850	80 850	80 850
b)Beverages		21 168	21 756	22 050	22 836	22 836
-full pension (full pens. * 3)						
Total revenues F&B		91 728	94 276	102 900	106 568	114 180
2.**Food&beverage**	26					
b) Full Pension		100%	100%	100%	100%	100%
Number of consumptions		7 056	7 252	7 350	7 612	7 612
*Proceeds/guest		10	10	11	11	12
=full pension		70 560	72 520	80 850	80 850	80 850
b)Beverages		21 168	21 756	22 050	22 836	22 836
-full pension (full pens. * 3)						
Total revenues F&B		91 728	94 276	102 900	106 568	114 180
3. Telephone revenues	3	10 311	10 560	11 750	12 170	13 214
4. Shopping revenues						
5. Other revenues for rental						
TOTAL REVENUES		**354 040**	**363 874**	**403 399**	**417 828**	**458 674**

OPERATING EXPENSES 1.Personnel Expenses number of employed Year's salary per employed Personnel Salary Insurance Personnel Expenses	28. 1	37 1 440 36 000 13 500 67 500	37 1 4040 36 000 13 500 67 500	37 1 560 39 000 14 625 72 345	37 1 560 39 000 14 625 72 345	37 1 620 40 500 15 187 75 127
2. **Cost of goods sold**	19. 1	45 864	47 138	51 450	53 284	57 090
3. F&B for the personnel (3 USD/day)	13	31 500	31 500	32 625	32 625	32 625
4. Direct expenses Phone+fax; laundry+cleaning	3	7 080	7 277	8 068	8 356	9 073
5. Indirect Expenses - energy, water - Maintenance - Small wares - Travel expenses - Insurance - Advertising - Marketing+Management - Office material - Bensol - Transport ***TOTAL***	11. 9	28 677	29 474	32 675	33 844	37 152
VAT, 20%		59 511	61 164	67 969	70 402	77 565
TOTAL OPERATING EXPENSES		**240 132**	**244 053**	**265 132**	**270 856**	**288 632**
GROSS OPERATING PROFIT		**113 908**	**119 821**	**138 267**	**146 972**	**170 042**

REPAYMENT OF THE CREDIT

Table 3

Moderate credit 1 300 000 USD
Interest: 3%
Repayment period 15 years

Financial bases	Years				
	1st	2nd	3rd	4th	5th
GROSS OPERATING PROFIT	113 908	119 821	138 267	146 972	170 042
Interest			39 000	39 000	39 000
Credit repayment	101 908	104 821	83 095	89 972	112 042
Cumulating credit repayment	101 908	206 729	289 824	379 796	491 838
Cash flow	12 000	15 000	17 300	18 000	19 000

Financial bases	Years				
	6th	7th	8th	9th	10th
GROSS OPERATING PROFIT	170 042	170 042	170 042	170 042	170 042
Interest	39 000	39 000	39 000	39 000	39 000
Credit repayment	112 042	112 042	112 042	112 042	112 042
Cumulating credit repayment	603 880	715 922	827 964	940 006	1 052 048
Cash flow	19 000	19 000	19 000	19 000	19 000

Financial bases	Years				
	11th	12th	13th	14th	15th
GROSS OPERATING PROFIT	170 042	170 042	170 042	170 042	170 042
Interest	39 000	39 000	39 000		
Credit repayment	112 042	112 042	23 868		
Cumulating credit repayment	1 164 090	1 276 132	1 300 000		
Cash flow	19 000	19 000	19 000	170 042	170 042

payback is 13 years for one hotel-SPA for first their phase, 40 beds (25 rooms), for one moderate credit of 1 300 000 USD.

12. WORK PROGRAMME

Methodology

This project must be implemented during the 3 years period, by the integration of the following phases:

FIRST PHASE.

The project must be realized using a complex of modern methods according to the objectives:

1. Complex and integrated study of all geothermal data on resources of geothermal energy in Albania:

- Integrated geothermal, hydrogeological, hydrochemical surveys in the sources and wells of geothermal energy.
- Mathematical modeling for calculation of potential of geothermal energy in Albania, as well as for the study of reservoirs.
- Geothermal and mineral water resources detailed feasibility study will be carried out in geothermal area. Project idea will be compiled, too.
- Technical projects will be compiled for investments in more perspective areas.

6 months

SECOND PHASE. 1. Construction of thermal water unit equipment in geothermal springs and wells.

2. Heating system, the thermal water unit equipment and

baths must be reconstructed in existing Hotels SPA. After second phase, all year SPA frequenting will realize. During the winter there are more demands for the medical treatment.

Good conditions in the SPA will help to have patient numbers increasing.

2. Green house, up to 3000 m^2 surface, must be constructed in the territory of thermal springs and wells

6 months

THIRTY PHASE: New Hotels-Clinic SPA hotel construction of (****) in geothermal areas. For the first time, the SPA Clinic and the hotel will have two or three floors, with the possibilities to build and 2 or three other floors in the future. In the ground floor will be located the restaurant, bar, medical clinic and thermal baths. Bedrooms will be located in the first and second floors. Thermal swimming pool will construct in the ground floor or in the yard.

24 months

FOUR PHASE: 1. Unit equipment for the extraction of chemical microelements and salts, CO2 and H2S gas will be designed and installed.

2. Unit equipment and collector for treatment and clearing the thermal water before their outflow will be designed and installed, to protect echo-system of the area.

3. Promotion and tourist agency will be organized. Put in full efficiency of all complex of the SPA will be completed.

10 months

13. ECONOMIC EVALUATION OF THE PROPOSED SCHEME FOR SPACE HEATING AND COOLING

A preliminary budget of the scheme Open loop: Borehole - Geothermal Heat Pump System for the one private residence. Two floor building has a total surface 460 m^2.

- Geothermal Heat Pump, with a heating capacity 42 kW, and cooling capacity 38 kW, after DELTA TECHNIKI Ltd Athens Greece, Athens, Greece price: 5 500 USD/unit
- Installation of the Geothermal Heat Pump System 1 800 USD
- Heating and cooling equipment (Fan-Coils, pipes etc) and its installation in the room 16.7 USD/m^3, for 1380 m^3 for all building 23 046 USD
- Providing water to the geothermal heating pump and re-injection of water in the collector after the use (Circulating pump, pipeline), according to the price index in Tirana: 7 500 USD.

Total 37 846

- Expenses for electrical energy, for 24 hours non-stop use of the heating and cooling system:
  - Water circulating pump 6 570 kWh/year.

- For Coefficient of Performance of the system C= 4, 87 600 kWh/year,

Total 94 170 kWh/hour or 23.3 Wh/m^2

After the literature data, in Switzerland for heating of a private residence, with geothermal pumps, the installation costs is 28 500 Swiss Francs, whereas the heating of a residence by gas boiler costs 21 000 Fr. (Rybach L. et al., 1995, 2000).

Direct use of the Geothermal Energy in Albania must start as soon as possible, first of all for the solving of the space heating and cooling. Will be high economic effectiveness investment.

14. ECONOMIC EVALUATION OF THE PROPOSED SCHEME FOR GREENHOUSE CONSTRUCTION

Economical evaluation has been performed for the construction of the industrial glass greenhouse, with sections 3.20 x 3.00 = 9.60 m^2, and surface 500 m^2 (0.05 ha). Water source-heat pumps system will be used for greenhouse heating. Ten l/sec of water, by the temperature 15-16 ^{o}C, from the underground basin at the depth of 30 m, will be used for the heat pump supply.

14.1. Greenhouse construction costs:

- Construction works, greenhouse heating system equipment, ventilation equipment, irrigation equipment, electric equipment, in total

7 655leke x 500 m^2 = 3 827 500 leke or 32 000 USD

- Borehole, circulating line, heat pump and re-injection borehole**: 2 207 385 leke**

in total : 6 034 885 leke 50 300 USD or 100.6 USD/m^2.

For 15 year payback period, can be estimate that in Albania, annual construction costs will be:

402 325 lekë/year or **3 353** USD/year.

After Rafferty K., Boyd T. economical analysis (1997) result that:

- Greenhouse costs (include greenhouse and equipment) 122 – 153 USD/m^2
- Construction costs 78 - 87 USD/m^2

14.2. Operative expenses in the greenhouse:

Operative expenses in the greenhouse, in the relation to the total expenses, have this annual structure(Rafferty K., Boyd T):

• Work	40 – 50%	27.8 USD/m^2
• Plants and materials	16 – 25%	13.4
• Heating, electric energy, lighting, water	6 – 16%	7.2
• Credite and siguracioni payments	17 – 19%	11.8
• Miscellaneous	8 – 10%	5.2
	Total	**65.4** USD/m^2

After Albanian farm experience total operative expenses for the projected greenhouse with a surface 0.05 ha, these expenses can be **45000** lekë/year**.**

Feasibility study:

1. ***Greenhouse expenses:***
   - Construction 402 325 lekë/year
   - Total operative expenses 45 000 lekë/year
   - Electric energy expenses:
     - Heat pump system:
       83.5 kWh x 376.8 orë x 9 lekë = 282 564 lekë/year
     - Water circulating pump:
       4.2 kWh x 376.8 x 9 lekë = 14 243 lekë/year

Total annual expenses for the projected greenhouse are 744 132 lekë or **6 200** USD

2. Greenhouse production:

Kind of production: Tomato. Greenhouses produce in Albania is 2000 kv/ha.year. Average price is 111.1 leke/kg. Consequently for the 0.05 ha greenhouse production income will be:

1 111 000 lekë/year or **9 258** USD/year.

Consequently for projected greenhouse, with a 15-year payback, result that:

- Income 9 258 USD/year
- Expenses 6 200 USD/year

Consequently, geothermal heating greenhouses represent an economic effective investment. Normally, the incomes will be bigger for the flower or olive plant cultivation in the greenhouse.

In the existing greenhouses, the heating system construction will have only a cost 488 966 leke/year or 4 100 USD/year, for a 15 years payback period. For a 10myears payback period the expenses will be 562 545 lekë/year or 4 700 USD/year, and investment will be profitable.

15. GATHERING INFORMATION MATERIAL AND KNOWLEDGE DISSEMINATION IT IS VERY IMPORTANT ELEMENT OF UTILIZATION OF GEOTHERMAL ENERGY

Task 1

Information material concerning the general principles of geothermal application and new technologies will be gathered and created. An information booklet and posters will be published and distributed to possible users.

Task 2. Establishment of communication channels with local users

Communication with local authorities will take place in order to find the end users, especially those capable of installing geothermal applications. Direct personal contacts with end users will also take place.

The investigators will implement this study by answering and focusing on the solution of the following questions:

The selection of the most suitable utilization plan according to the actual applications of the new technologies in question, the energy conservation, the desired transfer of the innovative technology to country, the probable users intentions and the existing heating consumption needs of the planned innovative applications.

The investigation of any probable environmental impact and the selection of the most suitable method for the disposal of the geothermal fluids to avoid possible environmental problems.

The selection of the best possible network for the geothermal fluid transport to ensure the violability of the utilization carrier, a single disposition price and the disposition of considerable quantities of energy (converted in TOE-s).

Task 3.

- To creates ready for use permanent educational and informative structures.
- To provide a useful tool for the education and information of geothermal energy end users
- For further dissemination of the results of this projects will organize days of open conferences. Workshops, seminars, TV and radio-emissions, pamphlets, posters, and summer school will organize. .In parallel, the strategies presented for the geothermal energy exploitation will be announced and criticized during these activities. The participant will originate from the public sector, user's, associations, Technical Chambers, higher educational institutes etc. Finally, material from Phase C will be also forwarded to the public authorities that are responsible for the awareness of users and therefore in close contact with them.
- To introduce, via an attractive method, the concepts of geothermal energy utilization and new technology transfer in the third level education

16. SIGNIFICANCE OF THE PROJECT PROPOSAL AND ITS EXPECTED ACHIEVEMENTS

The project proposal has great importance for Albania:

Firstly, it creates the scientific knowledge base for evaluation of natural wealth of geothermal energy and mineral waters in Albania. These data will be used to evaluate and select the rich areas in country. In these areas it is possible to start the investment for complex exploitation of geothermal energy and mineral water resources

Secondly, transfer of new methods for R&D and evaluation of geothermal water resources, modern technologies and unit equipment for thermal waters exploitation in Albania.

Thirdly, a technical and organizing base for modern hotel SPA construction will be created.

Thermal and mineral water springs, usually, are located in coastal or very beautiful mountainous regions of the Albania. The tourism will be developed. Thermal waters of low enthalpy will be used for the heating of green houses and SPA hotels and tourist villages near the springs. Extraction of chemical micro- elements as Iodine, Bromine, Borax, various natural salts from thermal and mineral waters, CO_2 and H_2S gas, will be achieved by installing the necessary equipment. Drinking-mineral water installations will be constructed. This development will create new working posts and will ameliorate the life conditions and level for habitants in thermal and mineral water spring areas.

Fourthly, new modern studying technologies will be disseminated in scientific and business community of country.

Fifthly, Environmental protection and preserving level will be improved, to well assist the echo-system protection of thermal and mineral water source areas.

17. CONCLUSIONS

1.Albania has the resources of geothermal energy of low enthalpy, which is possible for integrated and cascade direct use as an alternative energy.
2. Resources of the geothermal energy in Albania are;
   a) Natural springs and deep wells with thermal water, of a temperature up to 65.5°C.
   b) Heat of subsurface ground, with an average temperature of 16.4^{o}C and depth Earth Heat Flow.
3. Construction of the space-heating system, using shallow borehole heat exchanger (BHE)-Heat Pumps systems present the most important direction of the use of geothermal energy in Albania.

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19. LIST OF CAPTIONS

The 5th Congress of
Balkan Geophysical Society
Geophysics at the Cross-Roads
International Conference and Technical Exhibition
10-16 May, 2009, Belgrade, Serbia

DIPOLE – DIPOLE ARRAY CONFIGURATION AND INVERSION IN THE FRAMEWORK OF THE RECIPROCITY PRINCIPLE

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Abstract

The dipole-dipole array configuration is considered as a symmetrical array in terms of the reciprocity principle. Aspects of IP data inversion theory are considered, as well as resolution capability and stability of inversion solutions are discussed. This analyze, demonstrates cases when the IP/Resistivity anomaly configurations observed with a C_1C_2-P_1P_2 (AB-MN) array is not the same as the one observed with a P_1P_2-C_1C_2 (MN-AB) reversed array. The analysis includes results of some 2D and 3D mathematical and physical modeling performed in the Institute of Informatics and Applied Mathematics, and in the "Ligor Lubonja" Laboratory of Geophysics at the Faculty of Geology and Mining, Polytechnic University of Tirana, Albania.

1. INTRODUCTION

In the practice of electrical prospecting are employed various array configurations. The location of the current and potential electrodes is defined from the geological tasks to be solved. The dipole – dipole array is one of the most common arrays in mineral exploration. This is considered a symmetrical array in terms of the principle of reciprocity, so when the current electrodes are respectively switched with potential electrodes the same responses in IP and resistivity values are observed. However, our recent mathematical and scale models indicate discrepancies in this regard in several cases. This can lead to inaccurate target location and negative drilling results. To avoid such situations, the electrode orientation in the survey line has to be considered in the interpretation.

2. PRESENTATION OF THE PROBLEM

The well-known reciprocity principle stands on the basis of many array configurations in electrical prospecting like Pole - Pole, Dipole - Dipole, Schlumberger, Wenner etc (Keller and Frischknecht 1966, Zabarovskyy 1943, 1963, Frasheri et al. 1985). "According to the theorem of the reciprocity, no changes will be observed in the measured voltage if the

placements of potential and current electrodes are interchanged. The reciprocity can readily be confirmed for an electrode array over a homogeneous earth" (Keller and Frischknecht 1966).

The heterogeneous medium presents a more complicated problem. Zabarovskyy (1943, 1963) based on the electrostatic phenomena science has been observed:

$$U_M = U_A = \alpha_{AM} \times Q_A = \alpha_{MA} \times Q_M$$

Where: Q_A, Q_M - Electrical charges

α_{AM} , α_{MA} - Coefficients dependant on the shape of bodies A and M, their reciprocal position and the boundaries of heterogeneity.

and equation $Q_M=Q_A$ will be true if coefficients $\alpha_{AM} = \alpha_{MA}$. On this basis Zabarovskyy (1943, 1963) has accepted that the principle of reciprocity is valid for heterogeneous media as well. Habberjam, G.M. (1967), doubt has been expressed about the validity of the reciprocity principle, from field experiments. Reciprocity principle has been discussed by Parasnis D.S. (1988), which has been observed: "Although the reciprocity theorem is often mentioned in books and papers on d.c. resistivity prospecting as well as in books on applied geophysics, no proof of it arbitrary conductivity distribution has, to the best of my knowledge, been given in geophysical literature". For vertical targets of thickness $d > a$ (a stands for dipole spacing) the principle of reciprocity is met while for d comparable and thinner than a, the asymmetry is noticed in intensity and shape of the twin responses (Keller and Frischknecht 1966, Frasheri et al 1985).

In homogeneous or linear media, as example 2D horizontally stratified section the principle of reciprocity is true for any surveying array. In a heterogeneous environment this principle is absolutely true for symmetrical four electrodes Schlumberger, Wenner and pole-pole (half-Wenner) arrays.

The dipole-dipole array presents a complex behavior. In IP method the principle of reciprocity application is more complicated. In several field surveys asymmetrical IP/Resistivity responses are observed with dipole – dipole array for opposite orientations of the potential and current electrodes in the survey line. To further investigate this phenomenon some mathematical models were carried out with a program of finite element method (Frasheri A. and Frasheri N. 2000). The mathematical computation of the IP effect is based on the Bleil 1953 and Seigel 1959 formulae. To perform the mathematical modeling and the inversion of IP data, we have used the Komarov's (1972) approach. For 3D modeling of IP effect from targets with massive texture in homogeneous medium we have transformed the Bleil formulae, using Green's formulae (Frasheri N. 1983, Frasheri A., Frasheri N. 2000). With the same method of finite elements, simultaneously with the IP effect, the apparent resistivity is calculated as well. Testing of the results of a mathematical IP models with a similar field situation and scale model indicates the accuracy of mathematical model is good (Fig. 1, 2, 3, 4, 5) (Frasheri A. 1989, Frasheri A. et al. 1994, Frasheri A and Frasheri N, 2000).

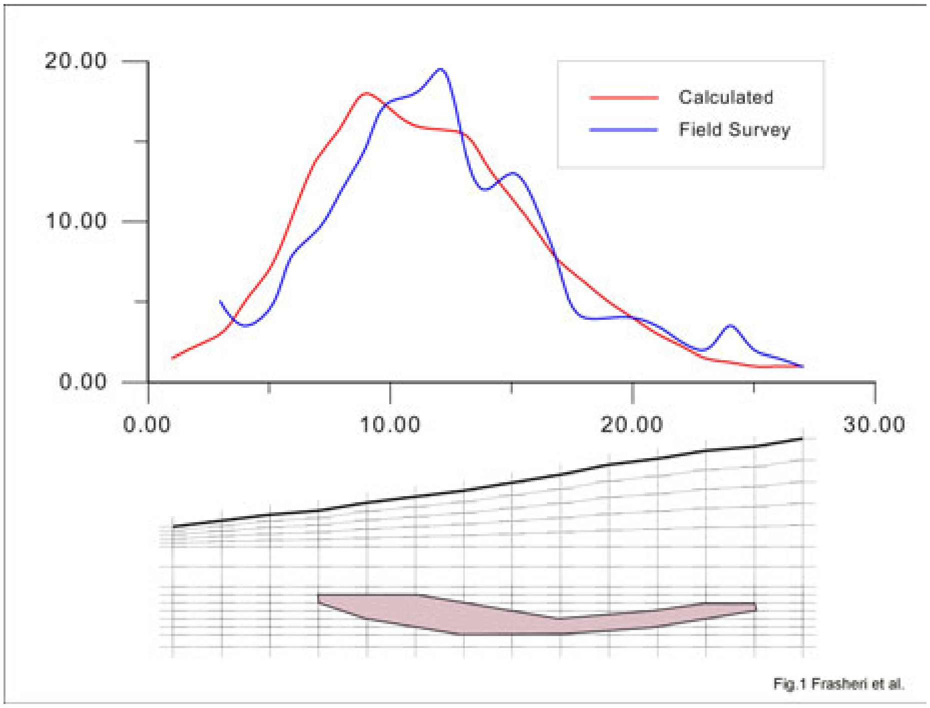

Fig. 1. A finite element section of an IP irregular body over a rugged relief.

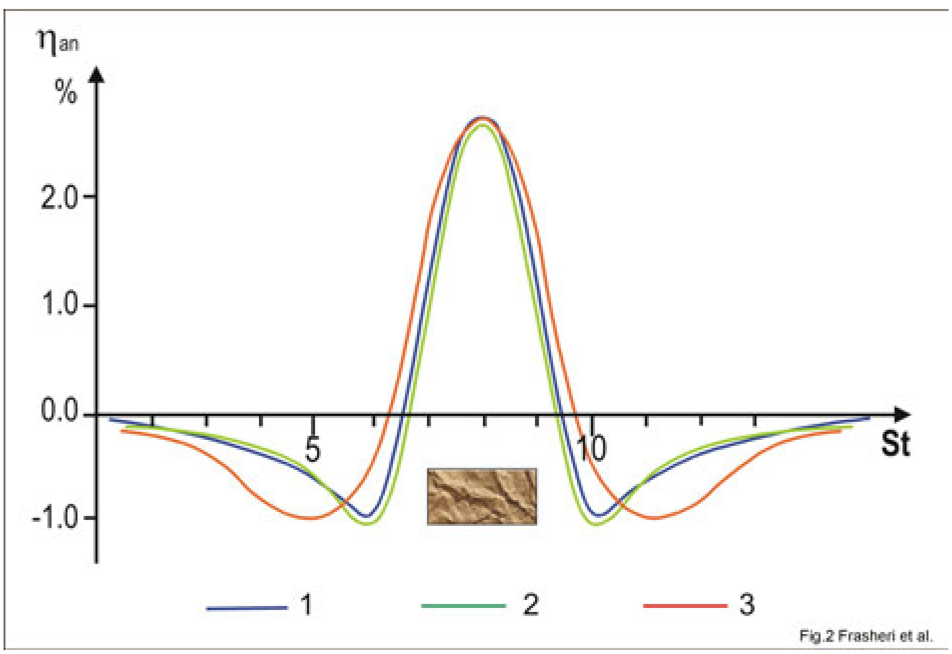

Fig. 2. IP profiling over a prism:
Theoretical (1);
Calculated by POLARELF Program (2); and
Physical modeling (3).

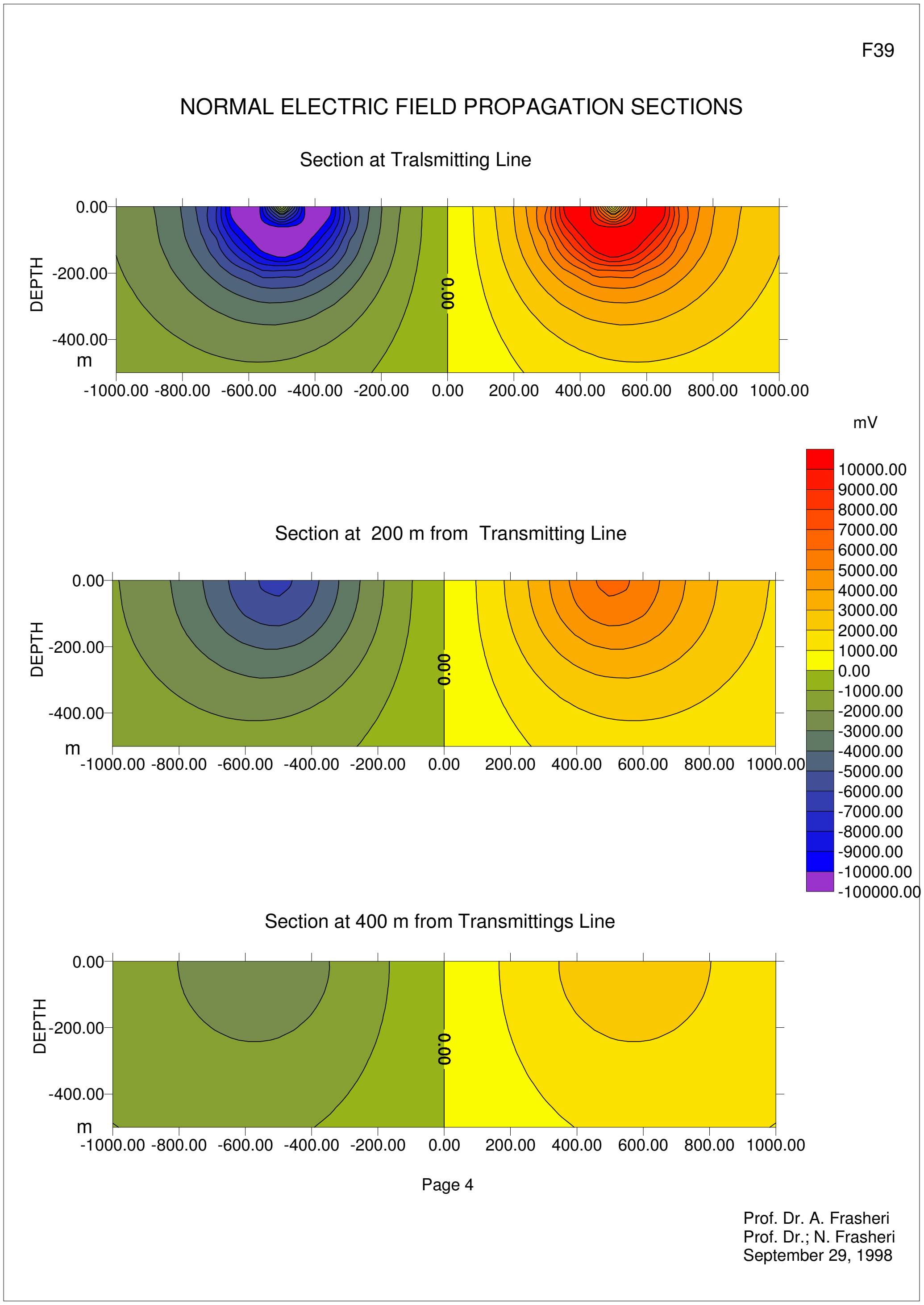
F39
NORMAL ELECTRIC FIELD PROPAGATION SECTIONS
Section at Tralsmitting Line
DEPTH
m
0.00
-200.00
-400.00
-1000.00 -800.00 -600.00 -400.00 -200.00 0.00 200.00 400.00 600.00 800.00 1000.00
mV
10000.00
9000.00
8000.00
7000.00
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
-1000.00
-2000.00
-3000.00
-4000.00
-5000.00
-6000.00
-7000.00
-8000.00
-9000.00
-10000.00
-100000.00
Section at 200 m from Transmitting Line
Section at 400 m from Transmittings Line
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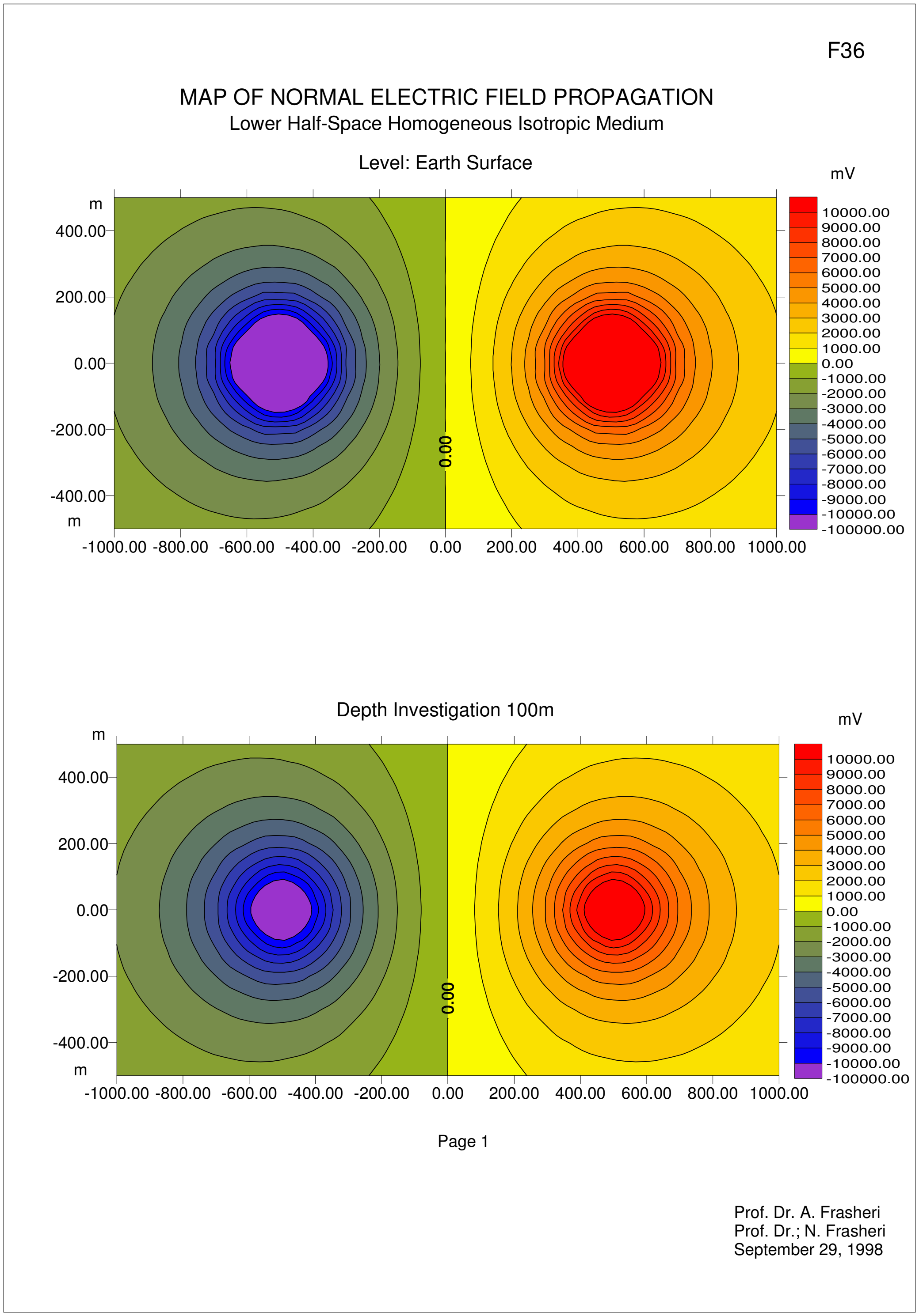
Fig. 3


F36
MAP OF NORMAL ELECTRIC FIELD PROPAGATION
Lower Half-Space Homogeneous Isotropic Medium
Level: Earth Surface
mV
m
400.00
200.00
0.00
-200.00
-400.00
m
-1000.00 -800.00 -600.00 -400.00 -200.00 0.00 200.00 400.00 600.00 800.00 1000.00
0.00
10000.00
9000.00
8000.00
7000.00
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
-1000.00
-2000.00
-3000.00
-4000.00
-5000.00
-6000.00
-7000.00
-8000.00
-9000.00
-10000.00
-100000.00
Depth Investigation 100m
mV
m
400.00
200.00
0.00
-200.00
-400.00
m
-1000.00 -800.00 -600.00 -400.00 -200.00 0.00 200.00 400.00 600.00 800.00 1000.00
0.00
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-8000.00
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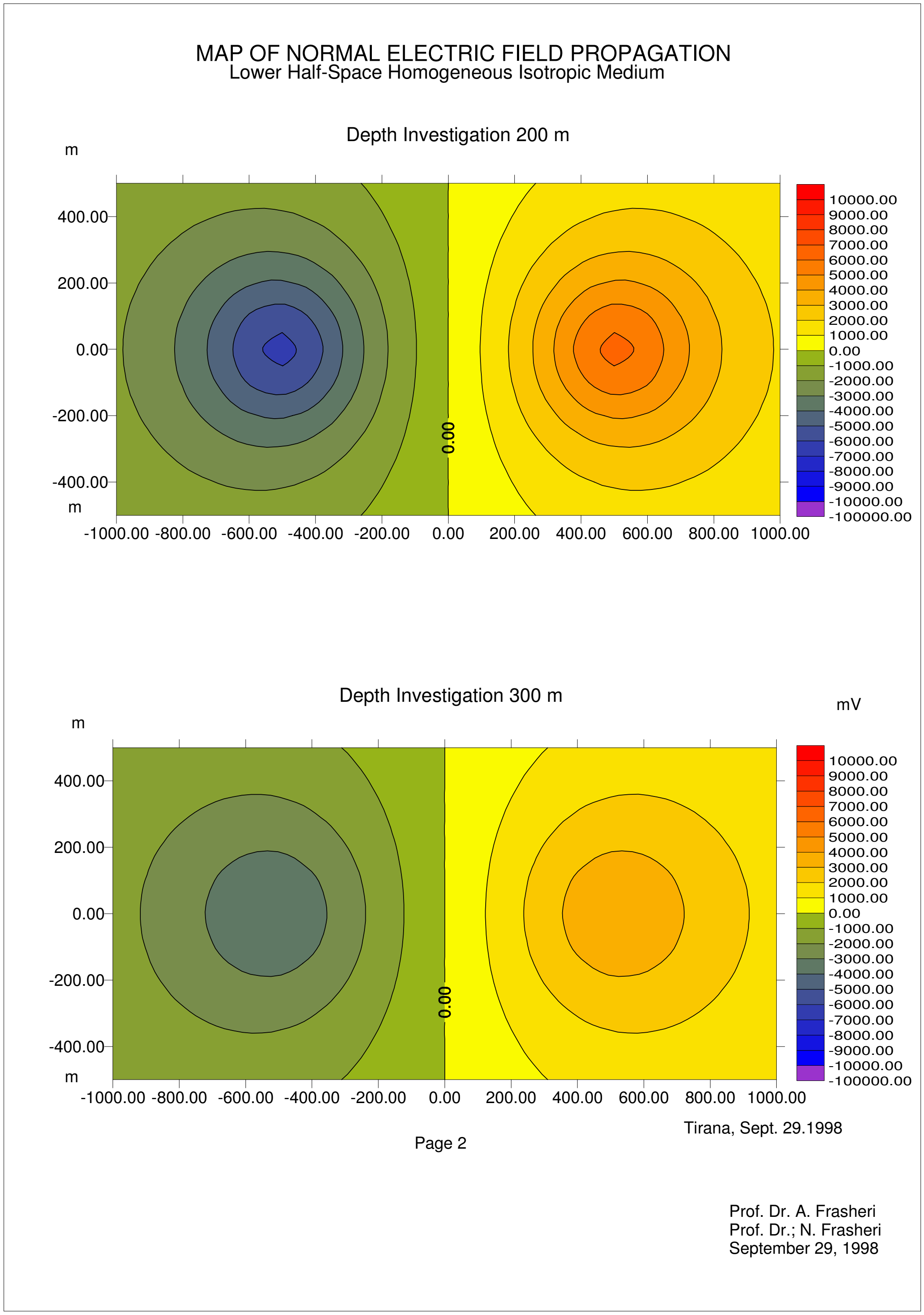
Fig. 4


MAP OF NORMAL ELECTRIC FIELD PROPAGATION
Lower Half-Space Homogeneous Isotropic Medium
Depth Investigation 200 m
m
400.00
200.00
0.00
-200.00
-400.00
m
-1000.00 -800.00 -600.00 -400.00 -200.00 0.00 200.00 400.00 600.00 800.00 1000.00
0.00
10000.00
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-5000.00
-6000.00
-7000.00
-8000.00
-9000.00
-10000.00
-100000.00
Depth Investigation 300 m
mV
m
400.00
200.00
0.00
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-400.00
m
-1000.00 -800.00 -600.00 -400.00 -200.00 0.00 200.00 400.00 600.00 800.00 1000.00
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-7000.00
-8000.00
-9000.00
-10000.00
-100000.00
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Fig. 5

The amplitude and the asymmetry of IP anomaly depend on the orientation of the polarizing vector of the primary electric field in connection to the prism location (Figs. 6, 7). The substantial difference between the electric field distributions in both cases clearly expresses the changes in IP anomaly configurations for gradient and dipole-dipole arrays.

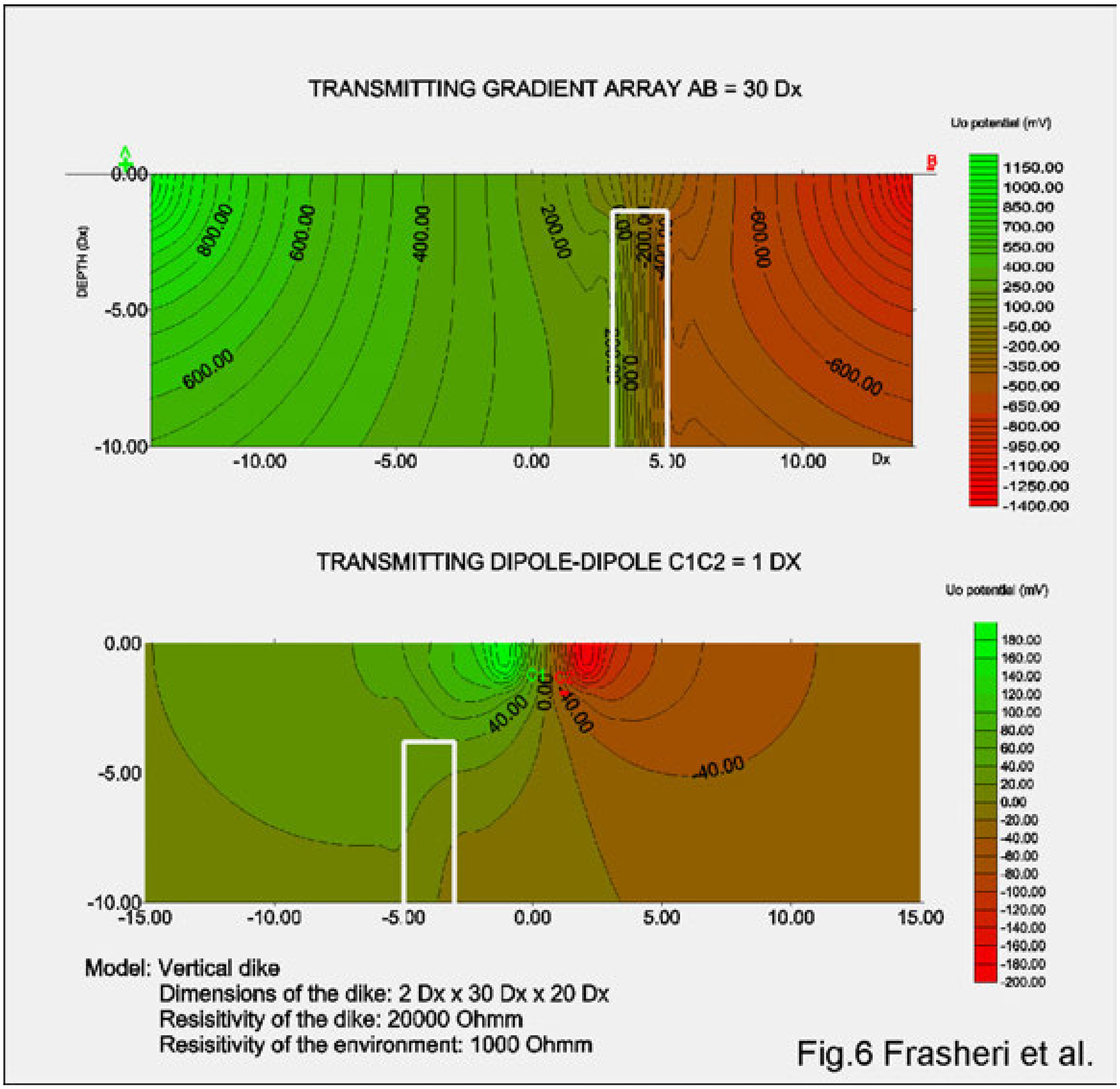


Fig. 6. Distribution of the primary electric field potential (Uo) of a transmitting dipole:

(a) Gradient array $AB_{max} = 30$ Dx

(b) Dipole-dipole array $C_1C_2 = 1$ Dx.

Mathematical model: Vertical prism. Dimensions of the prism 2 x 30 x 20 Dx, Resistivity of the prism 20,000 Ohmm, Resistivity of the environment 1,000 Ohmm.

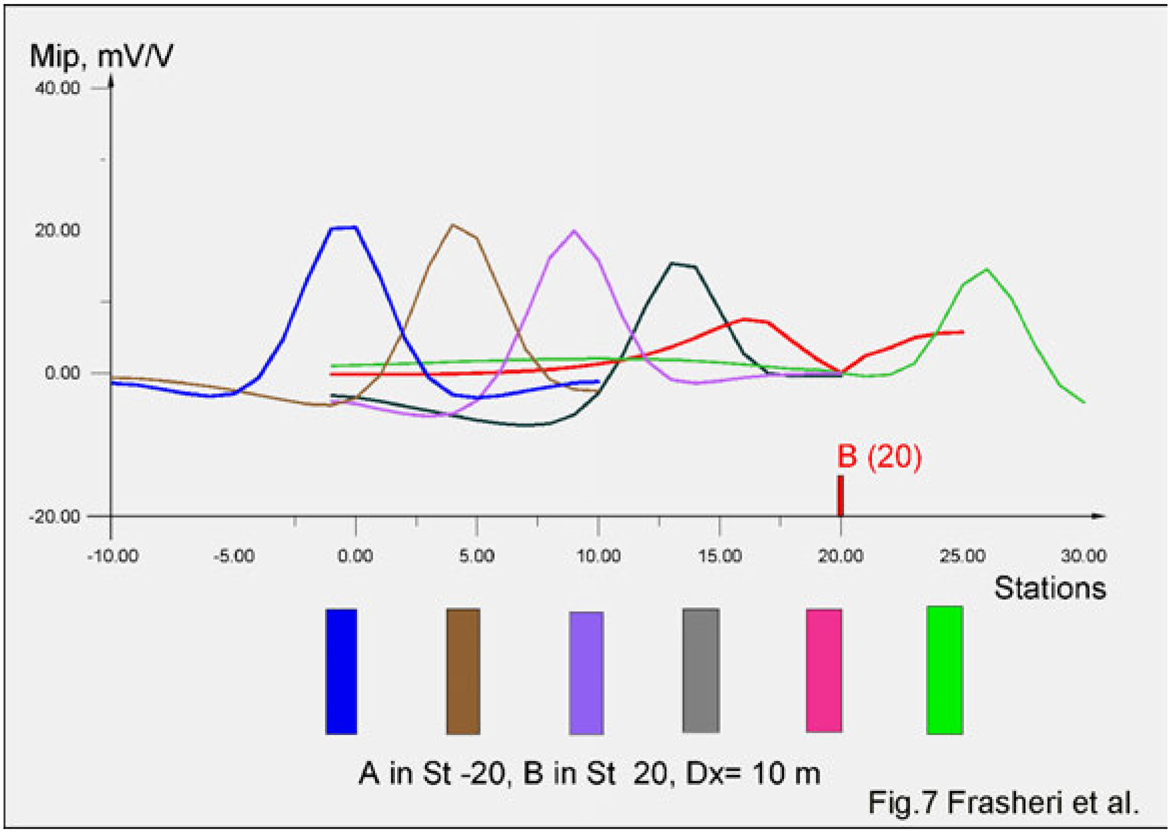


Fig. 7. IP anomaly configuration dependency on location of the target.
Mathematical model: Vertical prism.

3. NUMERICAL RESULTS FOR DIFFERENT MODELS

Fig. 8 present the mathematical model results of IP and resistivity responses with dipole–dipole profiling. Two anomalies are observed on both parameters. Considering the reference plotting point in between the potential electrodes P_1 and P_2, one of the anomalies is obtained over the prism while the second one at a distance O_1O_2 , between the centers of the current and potential dipoles. This presentation is conditioned on the distribution of the electrical field of the dipole - dipole array.

Because a mirror image is missing in the center of the profiles, especially for IP, it means that $C_1C_2P_1P_2$ array responses are not equivalent with $P_1P_2C_1C_2$, or in mathematical terms, the principle of reciprocity is not strictly met. Keller (1966) presents the same phenomenon for the apparent resistivity.

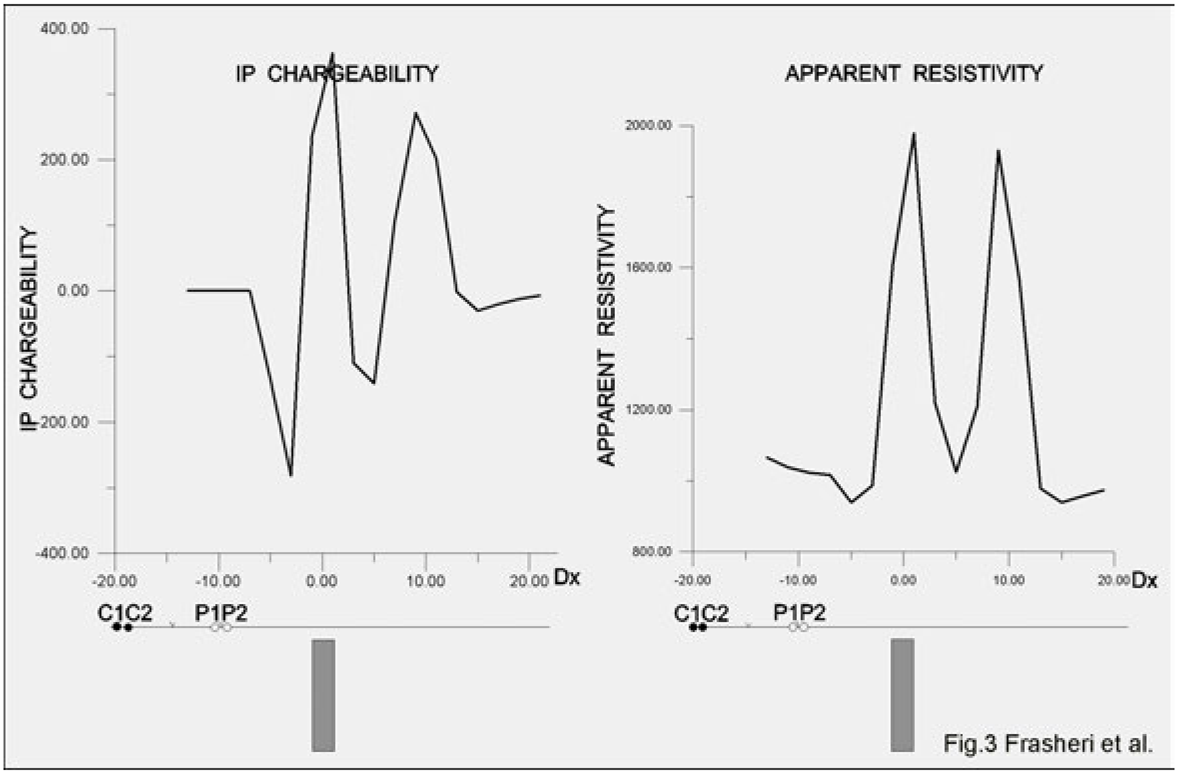


Fig. 8. IP and Resistivity mathematical modeling. Dipole-dipole profiling. C_1C_2-P1P2=2 Dx, n=1-10 Dx.
Model: 2D vertical prism at depth 1 Dx, dimensions of the prism section 2 x 9 Dx. Resistivity of the prism 20,000 Ohmm, IP Chargeability 500 mV/V, Resistivity of the environment 1,000 Ohmm, IP Chargeability of the environment 0.01 mV/V.

In pseudo section presentation, where the plotting point is located at the intersection of lines coming at 45° from midpoints between C_1C_2 and P_1P_2, these anomalies are located in both sides of the prism (Fig. 9, 10). For the resistivity parameter this location is almost symmetrical in shape and amplitude, for the vertical target (Fig:11, 12). The symmetry is perfect in cases when the thickness of the prism is equal or greater than the dipole spacing “a”, and becomes poor for thinner prisms (Fig. 11).

Alternatively, the IP anomalies are asymmetrical even in cases of vertical prisms (Fig. 11-a). In such cases, the epicenter of the most intensive anomaly is displaced on the side of current dipole C_1C_2. For shallow inclined prisms, the epicenters of both IP and resistivity anomalies are displaced on the opposite side of the dip.

The configuration of the IP/Resistivity anomaly is also dependent on the dip angle amplitude, relative to the current electrodes location (Fig. 11-b, c).

Asymmetrical IP and resistivity anomalies, depending on the location of current and potential dipoles in relation to target is not always without problems in manual or inversion interpretations of the IP/Resistivity data surveyed with a dipole–dipole array.

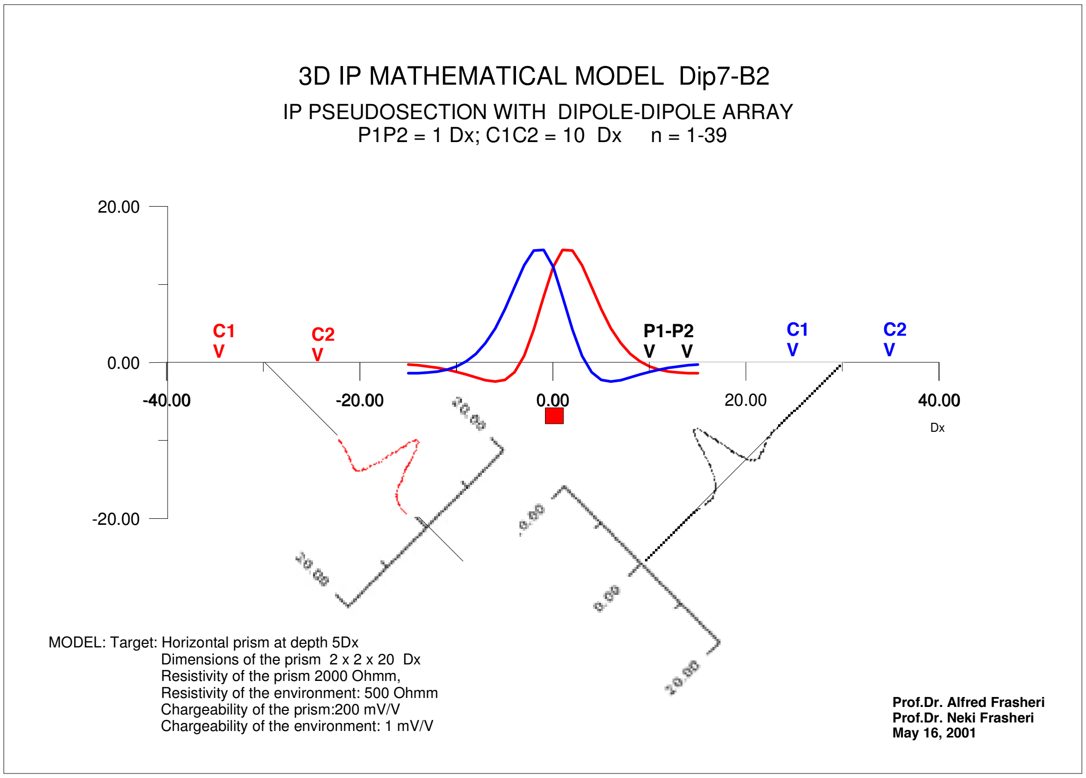
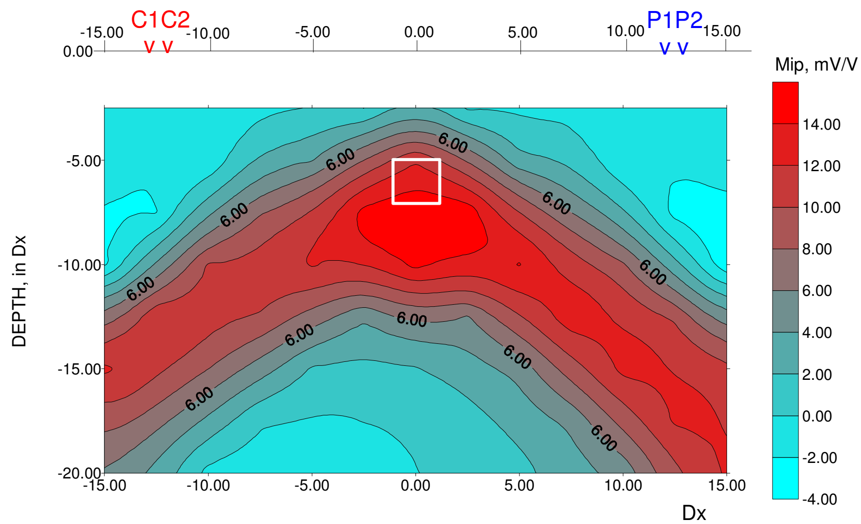


Fig. 9

Fig. 3

3D IP MATHEMATICAL MODEL Dip7-B2

IP PSEUDOSECTION WITH DIPOLE-DIPOLE ARRAY
P1P2 = C1C2 =1 Dx   n = 1-39



MODEL: Target: Horizontal prism at depth 5Dx
Dimensions of the prism 2 x 2 x 20 Dx
Resistivity of the prism 2000 Ohmm,
Resistivity of the environment: 500 Ohmm
Chargeability of the prism:200 mV/V
Chargeability of the environment: 1 mV/V

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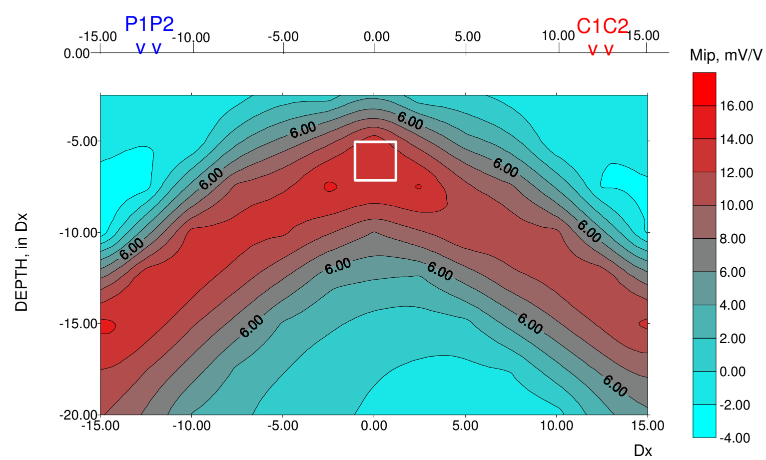
May 28, 2001

3D IP MATHEMATICAL MODEL Dip7-B2

IP PSEUDOSECTION WITH DIPOLE-DIPOLE ARRAY
P1P2 = C1C2 = 1 Dx   n = 1-39



MODEL: Target: Horizontal prism at depth 5Dx
Dimensions of the prism 2 x 2 x 20 Dx
Resistivity of the prism 2000 Ohmm,
Resistivity of the environment: 500 Ohmm
Chargeability of the prism:200 mV/V
Chargeability of the environment: 1 mV/V

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May 28, 2001

Fig. 10

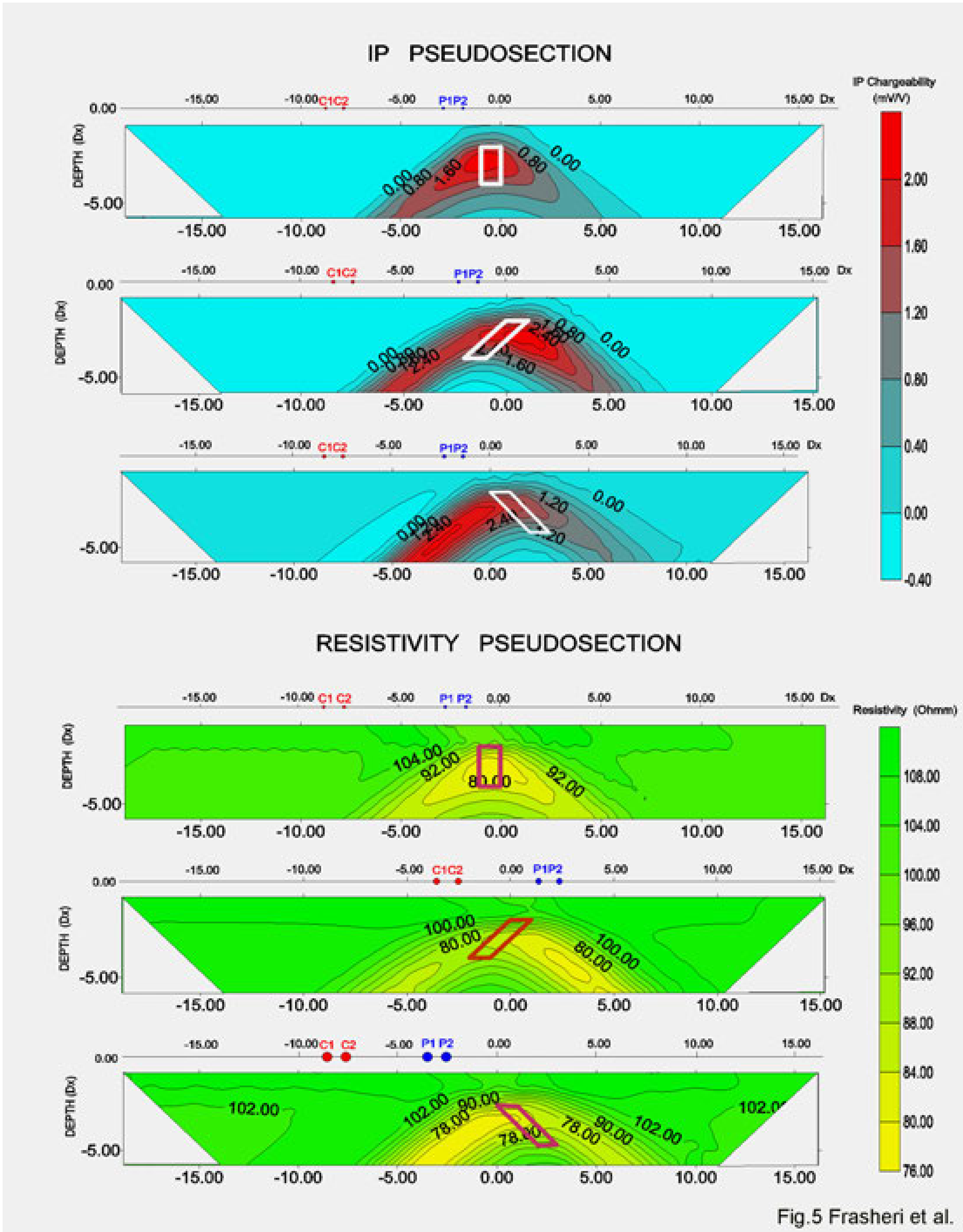


Fig. 11. IP and Resistivity Pseudo Section with dipole-dipole array, C_1C_2-P_1P_2=1 Dx, n=1-11 Dx. Mathematical model: 2D vertical prism at depth 1 Dx, dimensions of the prism section 4 x 50 Dx. Resistivity of the prism 3 Ohmm, IP Chargeability 50 mV/V, Resistivity of the environment 1,000 Ohmm, IP Chargeability of the environment 0.01 mV/V.

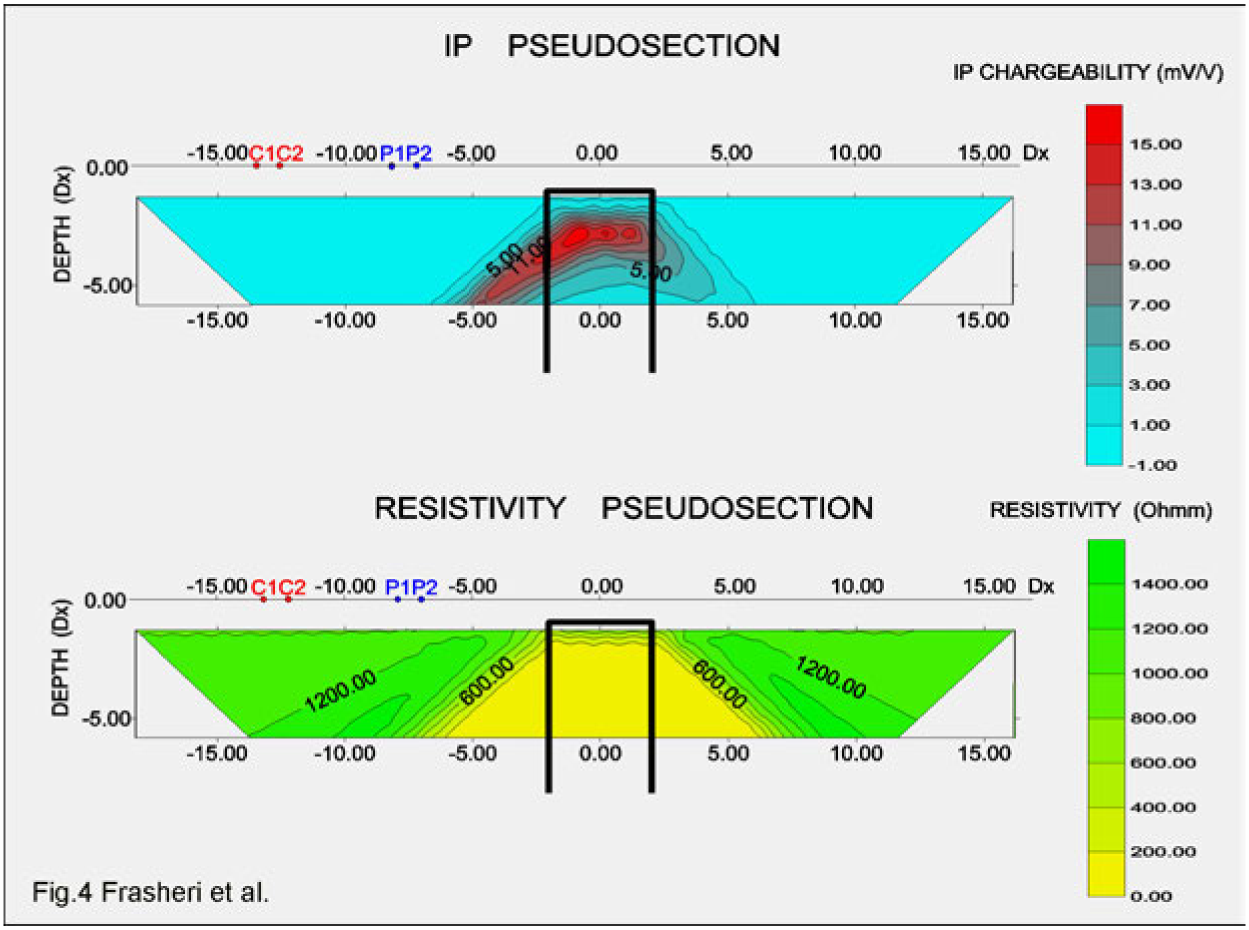


Fig. 12. IP and Resistivity Pseudo Section with dipole-dipole array. C_1C_2-P_1P_2=1 Dx, n=1-11 Dx. 2DMathematical model. Dimensions of the prism section 1 x 2 Dx. Resistivity of the prism 1 Ohmm, IP Chargeability 300 mV/V, Resistivity of the environment 100 Ohmm, IP Chargeability of the environment 0.01 mV/V.
a) vertical prism at depth 2 Dx, b) Inclined prism at depth 2 Dx, Western dip.
c) Inclined prism at depth 2 Dx, Eastern dip.

The response becomes more complicated when several targets are located under the surveying line. For a situation with two parallel polarizable inclined prisms like that in figs. 11 and 12, both C1C2P1P2 and P2P1C2C1 dipole-dipole arrays obtain a single IP anomaly in the centre and present some differences in contours shape (Fig. 13-a, b). A formal interpretation or even an inversion on these results cannot outline the presence of two distinct targets.

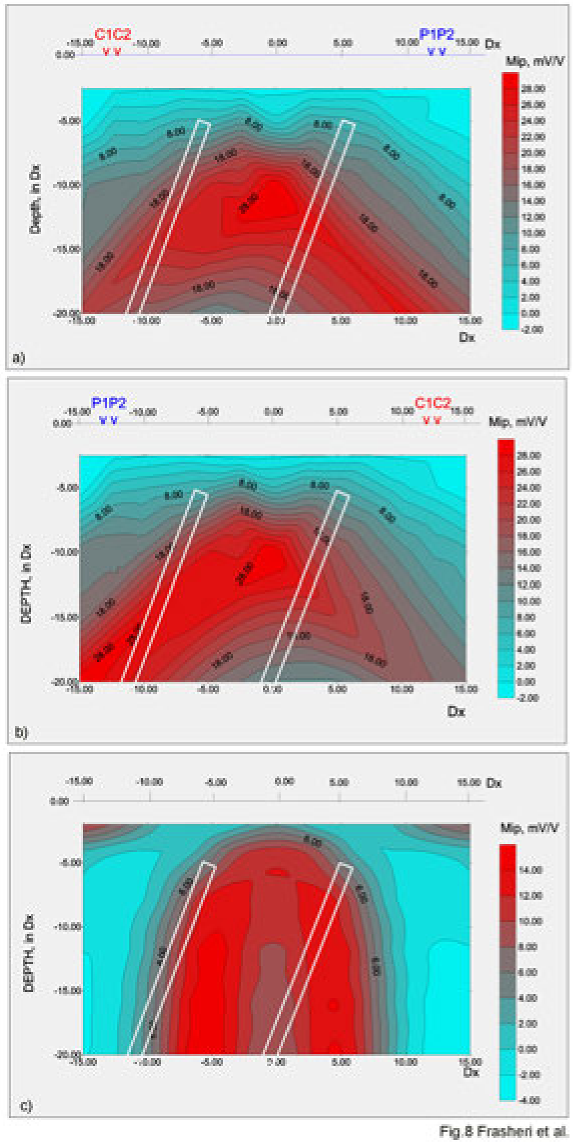


Fig. 13. IP Pseudo Section with dipole-dipole array, $C_1C_2=P_1P_2=1$ Dx, n=1-39.

Mathematical Model: Two parallel inclined prisms (dip=70^o) at depth 5 Dx, dimensions of the prisms 1 x 20 x 20 Dx. Distance between the prisms 10 Dx, Resistivity of prisms 2000 Ohmm, IP Chargeability 500 mV/V, Environment: Resistivity 500 Ohmm , IP Chargeability 0.01 mV/V.

a) Dipole-dipole $C_1C_2=P_1P_2$,
b) Dipole-dipole $P_1P_2=C_1C_2$
c) Real Section with multiple gradient arrays.

4. REAL SECTION

Limitations that are traditionally in traditionally configurations, as ex. “pseudosection” of the dipole dipole susvrey, has been overcome by gradient Realsection (Alikaj P. et al. 1981,). These limitations, that have been presented in the paragraph 3, existed with respect to location, resolution and depth of investigation, inherent in conventional configurations. The IP/Resistivity Realsection is a technique that employs the data acquisition from multiple gradient arrays or Schlumberger vertical soundings to provide a presentation that is close to real distribution of the geo-electrical parameters in a geologic section. It is not a mathematical inversion but rather a presentation of the physical measurements in compliance with general distribution of the electrical field at depth. Algorithm developed in conjucnction with these configurations, based on scale and mathematical modeling as well as orientation surveys over known deposits, allow presentation and interpretation of realsection technique in relation to real depth and location.

‘Realsection IP’ has come significant advantages over standard, double dipole or pole-dipole IP surveys, especially in depth of investigation and resolution. By using a short potential electrode distance (MN) the Realsection technique simultaneously provides with a high resolution of the near-surface IP/Resistivity targets (10-25 m) and a depth exploration capability (several hundred meters), this is not possible with conventional arrays.

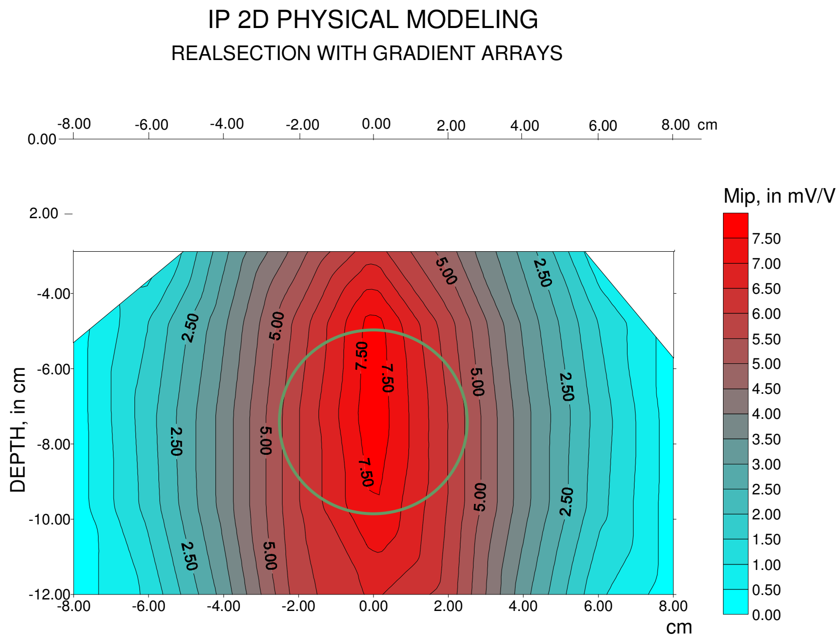
This method is turned to a specific depth of investigation by careful analysis of the geology and target model. The most common configuration is a gradient array. The first pass survey identifies zones worthy of detailed follow-uo. Each subsequent pass build the section from depth to surface. The survey is continually refined in the field to concentrate the detailing on the anomalies with the highest potential of exploration. ‘Realsection IP’ has overcome the difficulties with gradient arrays by providing vertical resolution. A significant advantage over the common array geometrics of pole-dipole and dipole-dipole is that an increase in depth of resolution can be incremented logarithmically or semi-logarithmically as opposed to arithmetically. ‘Realsection IP’ can be applied to sub-vertical or sub-parallel structures with equal effectiveness.

‘Realsecion IP’ is gaining acceptance for its ability to define depth narrow structure and for presenting this data in a section plotted at a depth that s calculated from the data and accurate to within 15% (Alikaj P., Gordon R.,)..

In the fig. 14-22 are presented ’Realsection IP’ of 2D Physical Modelling with gradient array for different shape polarizable targets, and 3D mathematical modeling of IP Realsections.

Mathematical model with IP Realsection array (Alikaj 1981, Langore Alikaj and Gjovreku 1989, Lubonja, Frasheri and Alikaj 1994) over the same targets, however, provides a different picture with two distinct anomalies (Fig. 13-c).

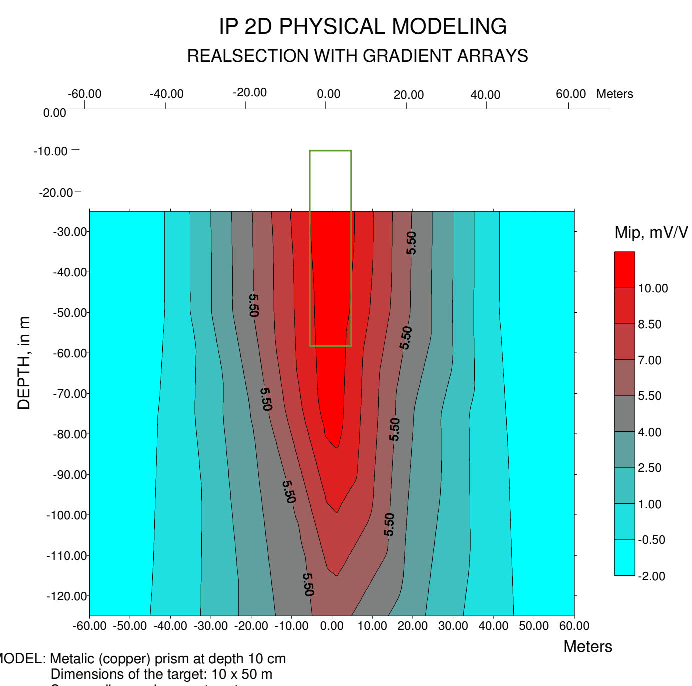
F28



MODEL: Metalic (copper) cylinder at depth 5 cm
Cylinder radius: 2.5 cm
Surrounding environment: water

Prof. Dr. P. Alikaj
July 1981

F29



MODEL: Metalic (copper) prism at depth 10 cm
Dimensions of the target: 10 x 50 m
Surrounding environment: water

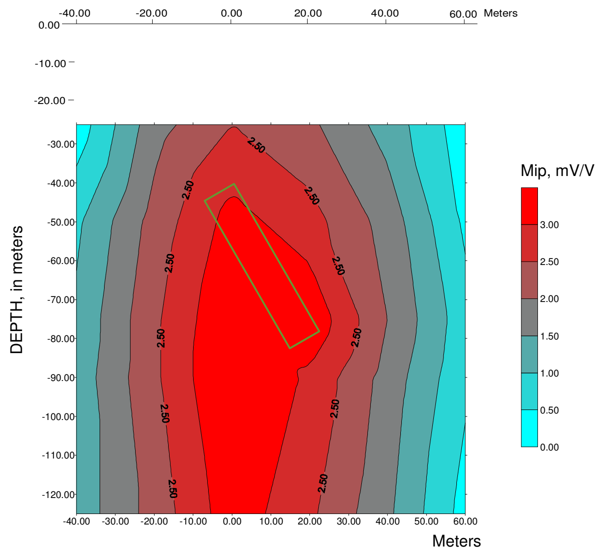
Prof. Dr. P. Alikaj
July 1981

Fig. 14

F30

IP 2D PHYSICAL MODELING

REALSECTION WITH GRADIENT ARRAYS



MODEL: Metalic (copper)inclined prism (dip=45o) at depth 10 cm
Dimensions of the target: 10 x 50 m
Surrounding environment: water

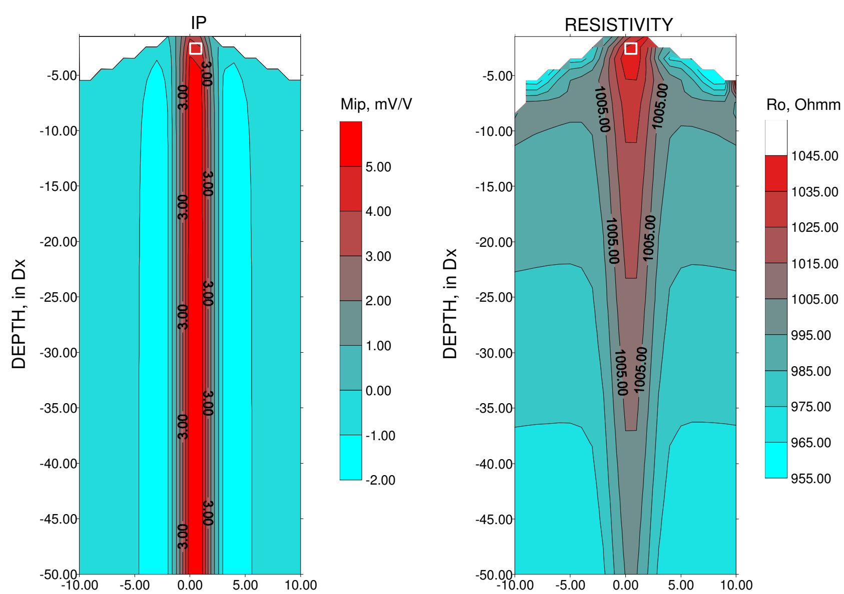
Prof. Dr. P. Alikaj
July 1981

Fig. 15

Fig. 2

3D IP MATHEMATICAL MODEL M6

REALSECTION WITH GRADIENT ARRAYS



MODEL: Prism at depth 2 Dx
Dimensions: 1 x 1 x 20 Dx
Resistivity of the prism: 2000 Ohmm; Resistivity of the environment: 1000 Ohmm
Chargeability of the prism: 100 mV/V: Chargeability of the environment: 1 mV/V

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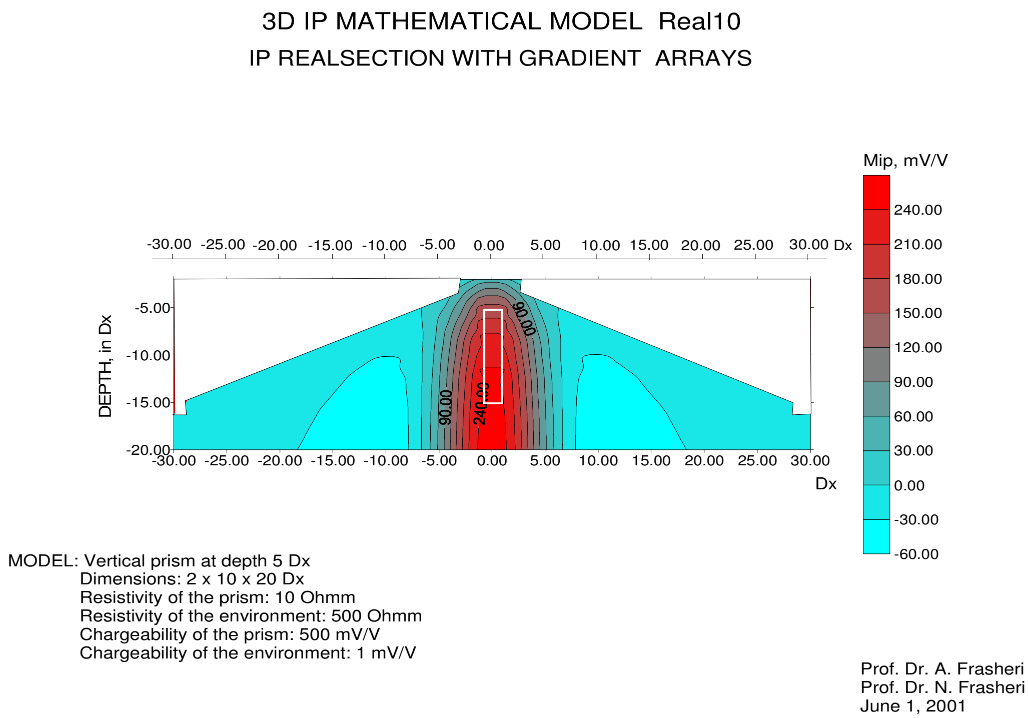
April, 2001

Fig. 16


3D IP MATHEMATICAL MODEL Real10
IP REALSECTION WITH GRADIENT ARRAYS
Mip, mV/V
240.00
210.00
180.00
150.00
120.00
90.00
60.00
30.00
0.00
-30.00
-60.00
-30.00 -25.00 -20.00 -15.00 -10.00 -5.00 0.00 5.00 10.00 15.00 20.00 25.00 30.00 Dx
DEPTH, in Dx
-5.00
-10.00
-15.00
-20.00
90.00
240.00
Dx
MODEL: Vertical prism at depth 5 Dx
Dimensions: 2 x 10 x 20 Dx
Resistivity of the prism: 10 Ohmm
Resistivity of the environment: 500 Ohmm
Chargeability of the prism: 500 mV/V
Chargeability of the environment: 1 mV/V
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Prof. Dr. N. Frasheri
June 1, 2001

Fig. 17

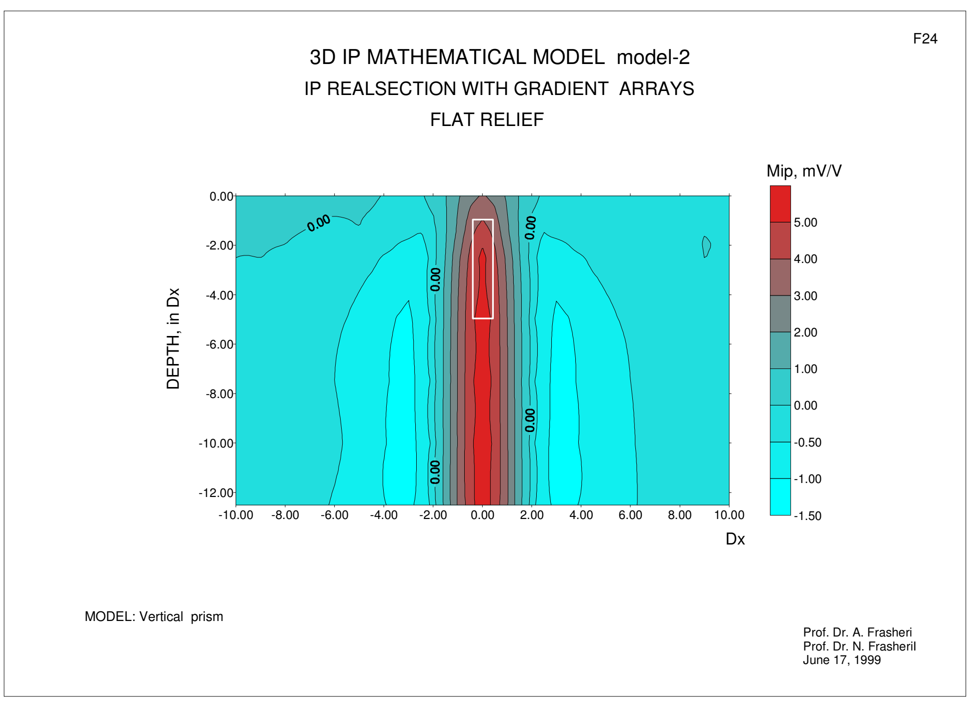
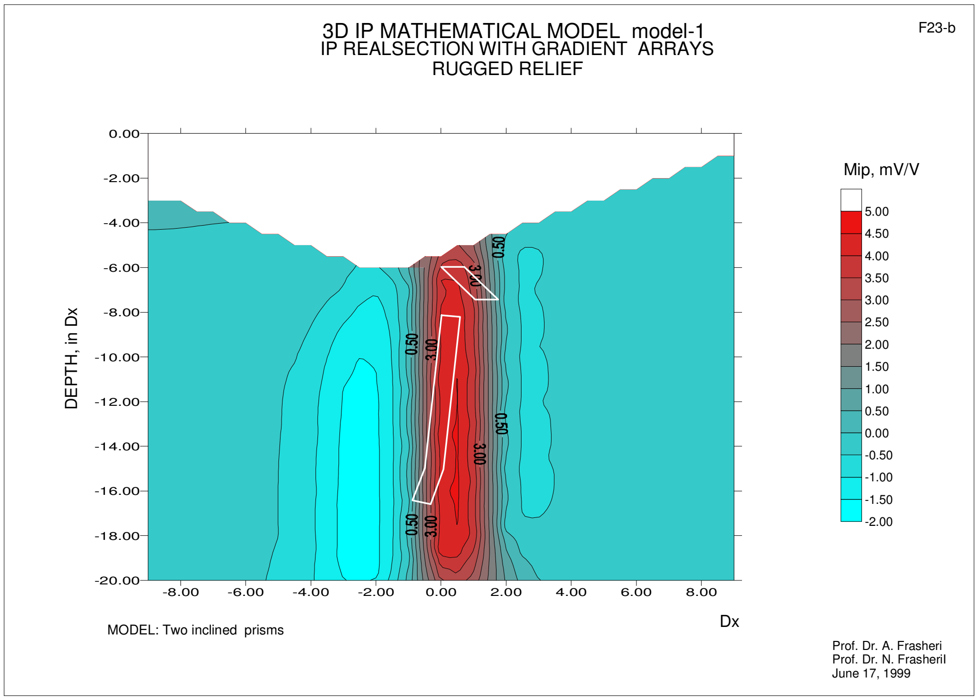

F24
3D IP MATHEMATICAL MODEL model-2
IP REALSECTION WITH GRADIENT ARRAYS
FLAT RELIEF
Mip, mV/V
5.00
4.00
3.00
2.00
1.00
0.00
-0.50
-1.00
-1.50
DEPTH, in Dx
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
-12.00
-10.00 -8.00 -6.00 -4.00 -2.00 0.00 2.00 4.00 6.00 8.00 10.00
Dx
MODEL: Vertical prism
Prof. Dr. A. Frasheri
Prof. Dr. N. Frasheril
June 17, 1999

Fig. 18


3D IP MATHEMATICAL MODEL model-1
IP REALSECTION WITH GRADIENT ARRAYS
RUGGED RELIEF
F23-b
DEPTH, in Dx
Dx
Mip, mV/V
MODEL: Two inclined prisms
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Prof. Dr. N. Frasheril
June 17, 1999

Fig. 19

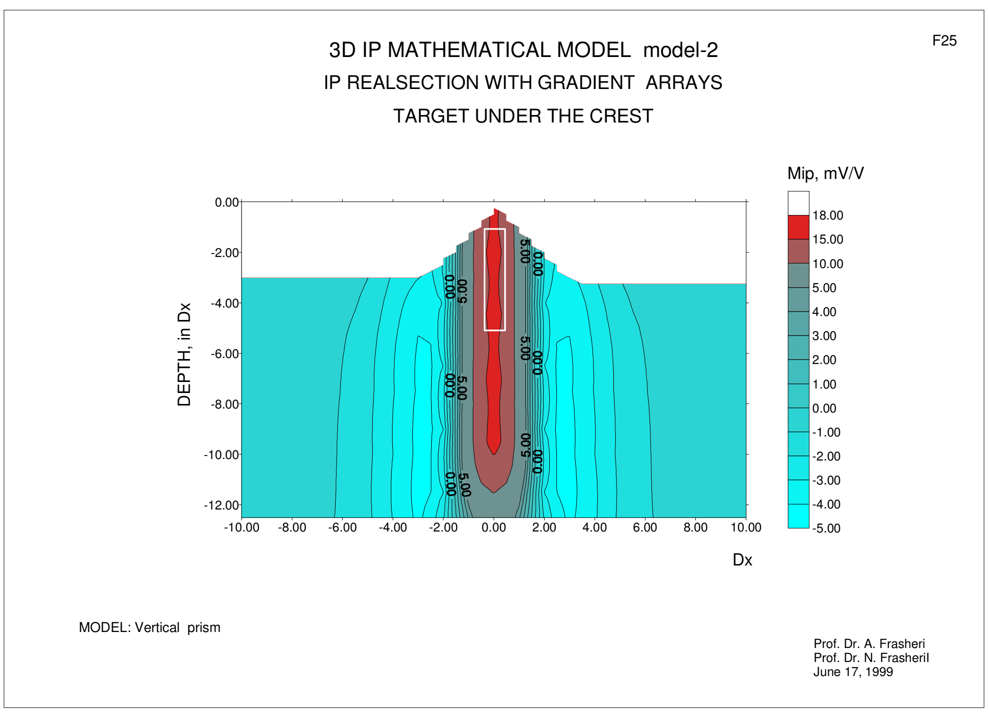
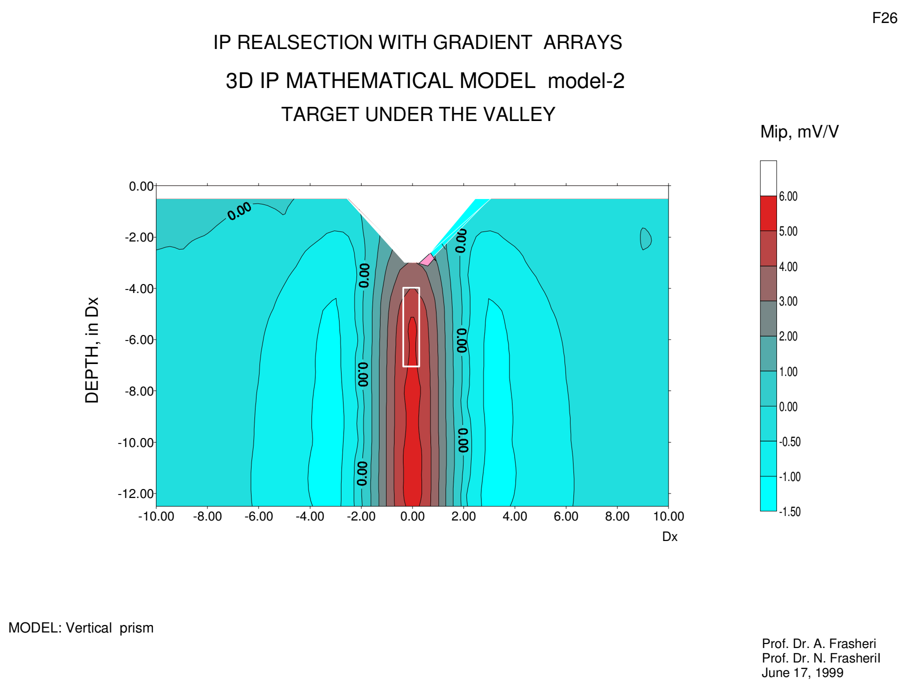

3D IP MATHEMATICAL MODEL model-2
IP REALSECTION WITH GRADIENT ARRAYS
TARGET UNDER THE CREST
F25
DEPTH, in Dx
Dx
Mip, mV/V
MODEL: Vertical prism
Prof. Dr. A. Frasheri
Prof. Dr. N. Frasheril
June 17, 1999

Fig. 20


F26
IP REALSECTION WITH GRADIENT ARRAYS
3D IP MATHEMATICAL MODEL model-2
TARGET UNDER THE VALLEY
Mip, mV/V
DEPTH, in Dx
Dx
MODEL: Vertical prism
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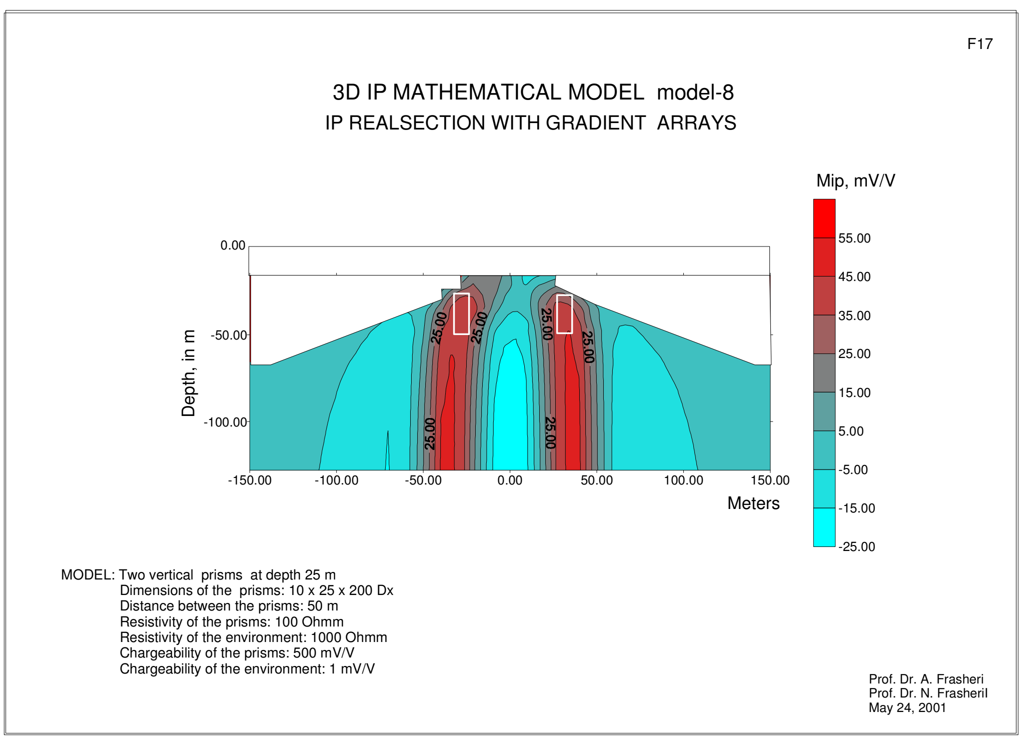
Prof. Dr. N. Frasheril
June 17, 1999

Fig. 21


F17
3D IP MATHEMATICAL MODEL model-8
IP REALSECTION WITH GRADIENT ARRAYS
Mip, mV/V
Depth, in m
Meters
MODEL: Two vertical prisms at depth 25 m
Dimensions of the prisms: 10 x 25 x 200 Dx
Distance between the prisms: 50 m
Resistivity of the prisms: 100 Ohmm
Resistivity of the environment: 1000 Ohmm
Chargeability of the prisms: 500 mV/V
Chargeability of the environment: 1 mV/V
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Prof. Dr. N. Frasheril
May 24, 2001

Fig. 22

5. SOME CONSIDERATIONS ON SO CALLED "IP DATA INVERSION"

The calculation of IP effect is based on the formulae of Bleil [Bleil D., 1953; Seigel H.O., 1959]:

$$U_{IP} = c \times \int_V \nabla U \times \left(\frac{1}{\vec{R}} \right) \times dv \qquad (1)$$

Where: U_{ip} is the IP potential;
$\vec{R}$ is the distance vector from the integration point to the receiving point;
∇U is the potential gradient of the primary electrical field, calculated by solving the finite element model.

The evaluation of Komarov is used for both modeling and inversion of IP data, supposing a formal similarity of environment polarization with the increasing of its electrical specific resistivity [Komarov V.A., 1972]:

$$C(Uo+Uip) \approx CUo \qquad (2)$$

Where: Uo- potential of the polarizing current field,
Uip- potential of the IP fiend
C- IP susceptibility

In all calculations, the effect of IP is supposed as linear. Such modeling and inversions of IP pseudo-sections, carried out by many authors, have been a step forward for the interpretation of IP survey data and for the evaluation of IP methods. But new facts on the non-linear nature of IP phenomenon, together with results of mathematical and physical modeling of last ten years, arise new problems with regard to P modeling and inversion. If these problems will remain unsolved, it would decrease the effectively of IP investigations.

Conception of IP as a linear phenomenon and its usage in equations of modeling and inversion creates several characteristics in the configuration of calculated mathematically IP anomalies:

1. The upper parts of anomalies correspond with the upper sides of the polarized targets.
2. Anomalies remain open towards the depth, even below the bottom sides of targets.

Continuation of IP anomalies below bottom sides of targets makes the interpretation difficult and its extension in depth as unsure. The presentation of anomalies is more complex, compared with pseudo-sections, for dipole-dipole and pole-dipole arrays. Migration of anomalies in pseudo-sections depends on the angle of inclination of targets and on the position of current and measuring electrodes relative to targets (there are left-arrays C1C2-P1P2 and right-arrays P1P2-C1C2). The reason of such configuration of IP

anomalies is due to the supposition, during mathematical calculations, that the IP has a linear dependence from the tension of polarizing electric field

Due to the different polarizing situations, IP phenomenon is characterized by:

1. Significant decrease of the intensity of polarizing electric field in depth. Increasing of investigation depth, different parts of the same target, as well as different targets in different depths, are situated in different polarizing conditions.
2. For the same depth of polarized targets, the intensity of polarizing electric field decreases by a great gradient relative when the distance AB of current electrodes increases (Fig. 23).

Polarizing field voltage (E) at the depth 50 meters,in the medium with resistivity of 1000 Ohmm.

Current Electrodes spacing [in meters]	Voltage of polarizing electric field [in mV/m]
100	33960
500	53
1000	13
2000	3
3000	1.4

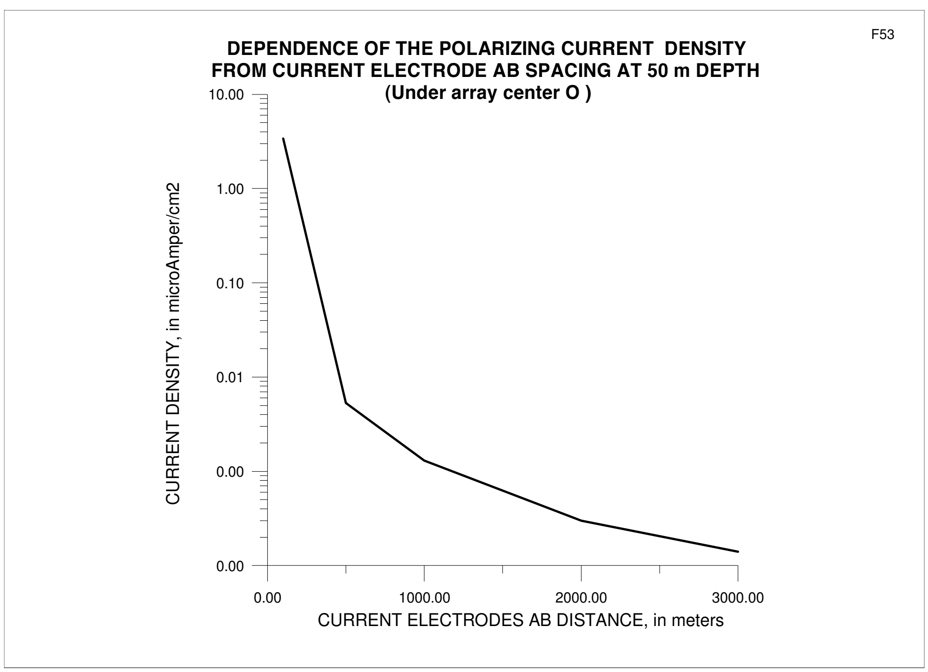


Fig. 23

3. Depending on the environment, the voltage of polarizing field varies with a greater gradient. As result, the decrease of density and tension of polarizing fiend in depth means, because of non-linearity, less polarization compared with what is received by linear models. As result, in real sections from physical modeling the IP anomalies close under targets .
4. The effect of distributed IP is defined from survey arrays. This distribution is symmetric for gradient arrays, but asymmetric for dipole-dipole arrays making obligatory the inversion of IP data.

The stability and uniqueness of IP inversion solutions depend also from the application of a linear model for the IP phenomenon, but that is not quite true for the whole variation of applied polarizing tensions. As result, the lower part of polarized targets is instable in IP inversions. It becomes more instable when several targets are situated near each other, or in cases of targets near contacts between environments with different polarizability. The increase of depth of targets causes the increase of instability for inversion solutions and of its resolution capability (Fig. 24). Target shape, it's dimensions and depth of location are conditioned inversion results and stability, too (Fig. 25, 26, 27).

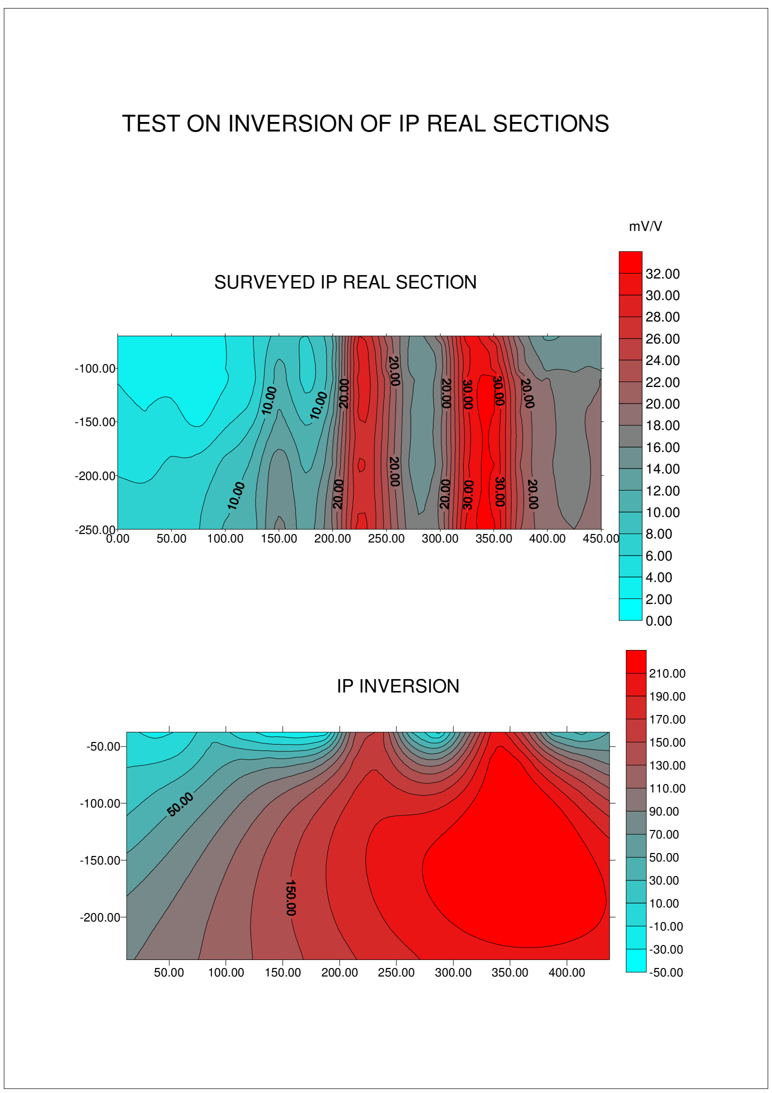
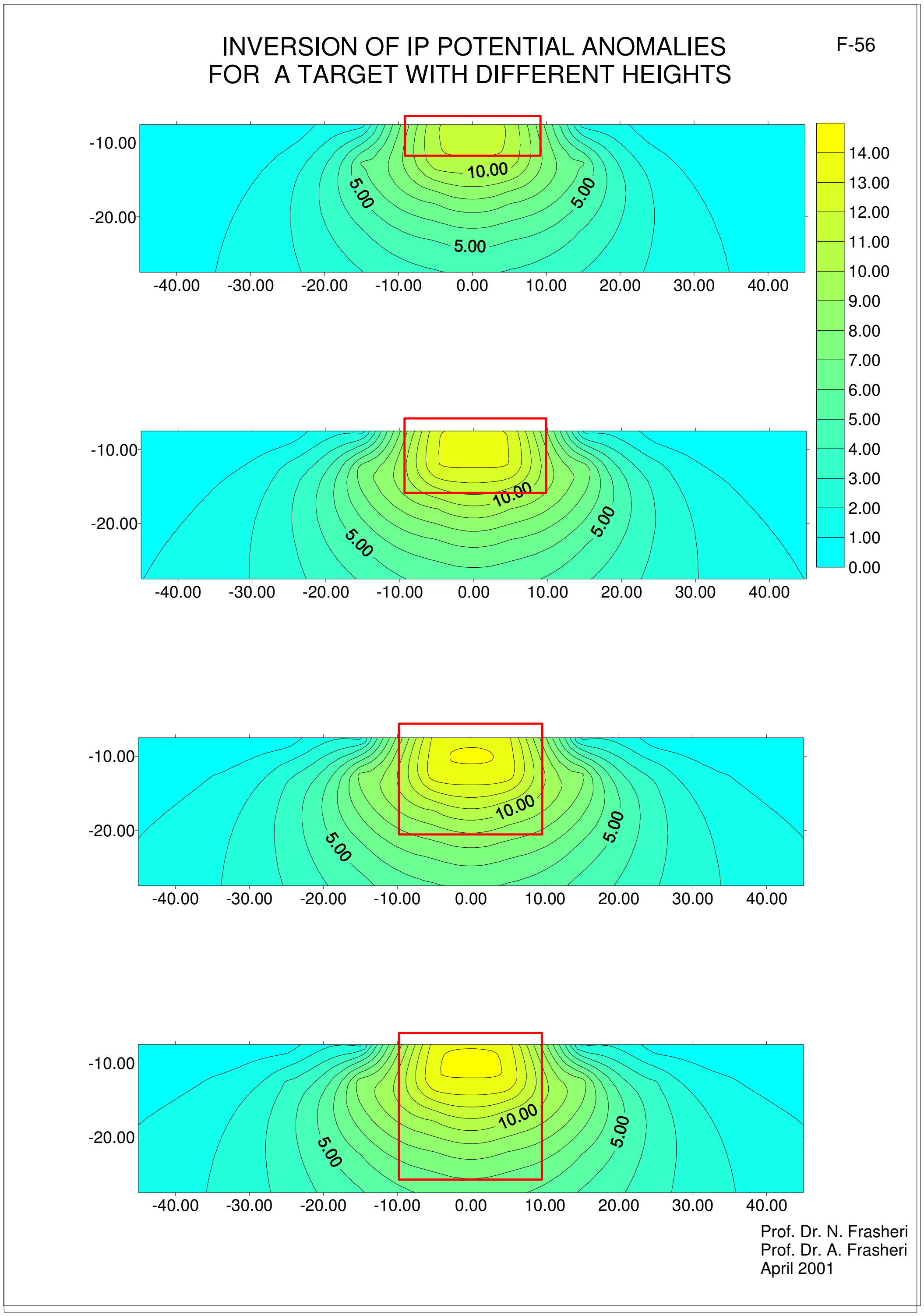


Fig. 24


INVERSION OF IP POTENTIAL ANOMALIES
FOR A TARGET WITH DIFFERENT HEIGHTS
F-56
-10.00
-20.00
-40.00
-30.00
-20.00
-10.00
0.00
10.00
20.00
30.00
40.00
5.00
10.00
14.00
13.00
12.00
11.00
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
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Prof. Dr. A. Frasheri
April 2001

Fig. 25

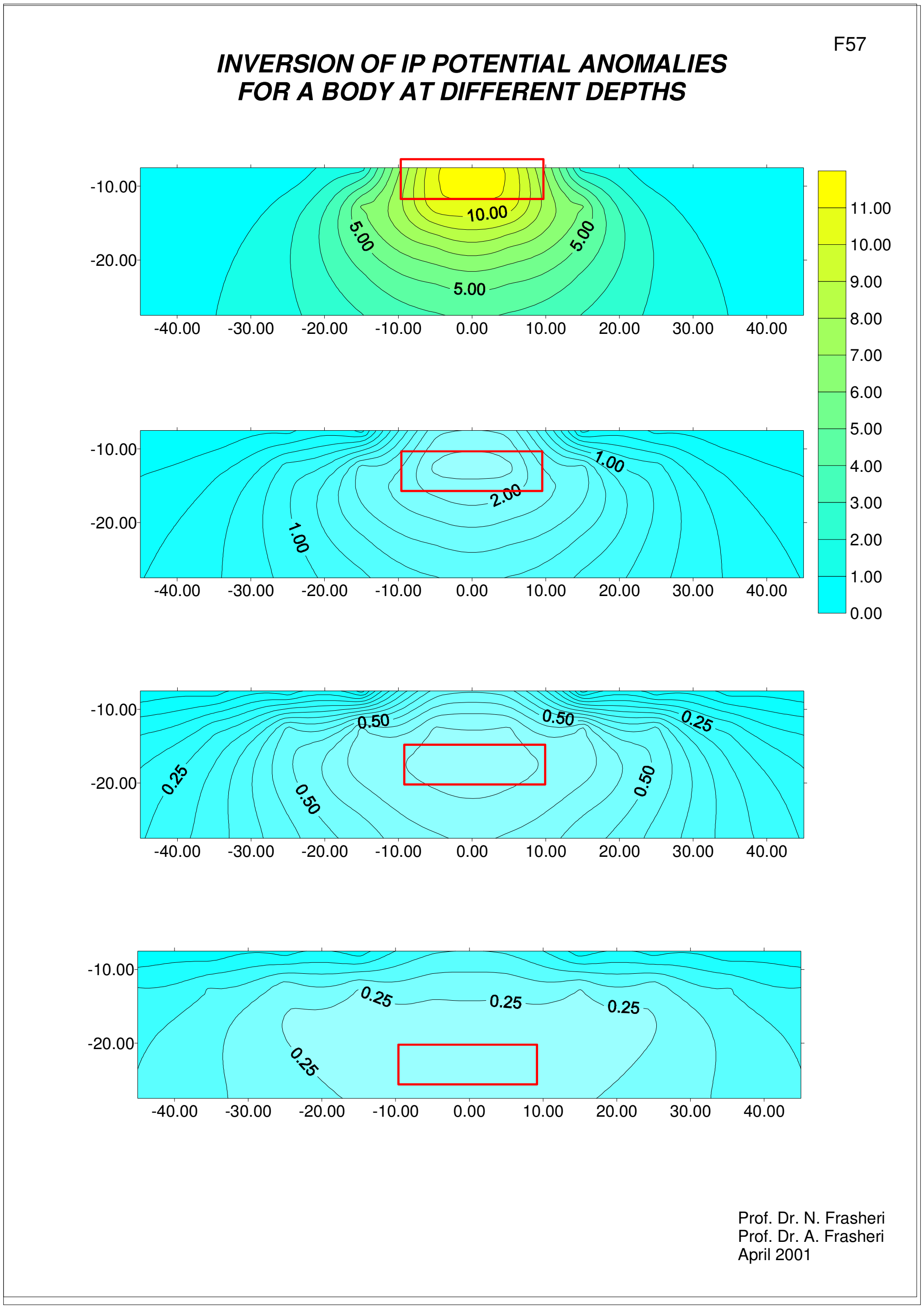
F57
INVERSION OF IP POTENTIAL ANOMALIES
FOR A BODY AT DIFFERENT DEPTHS
-10.00
-20.00
10.00
5.00
5.00
5.00
-40.00 -30.00 -20.00 -10.00 0.00 10.00 20.00 30.00 40.00
11.00
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
1.00
2.00
1.00
0.50
0.50
0.25
0.25
0.50
0.50
0.25
0.25
0.25
0.25
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Fig. 26

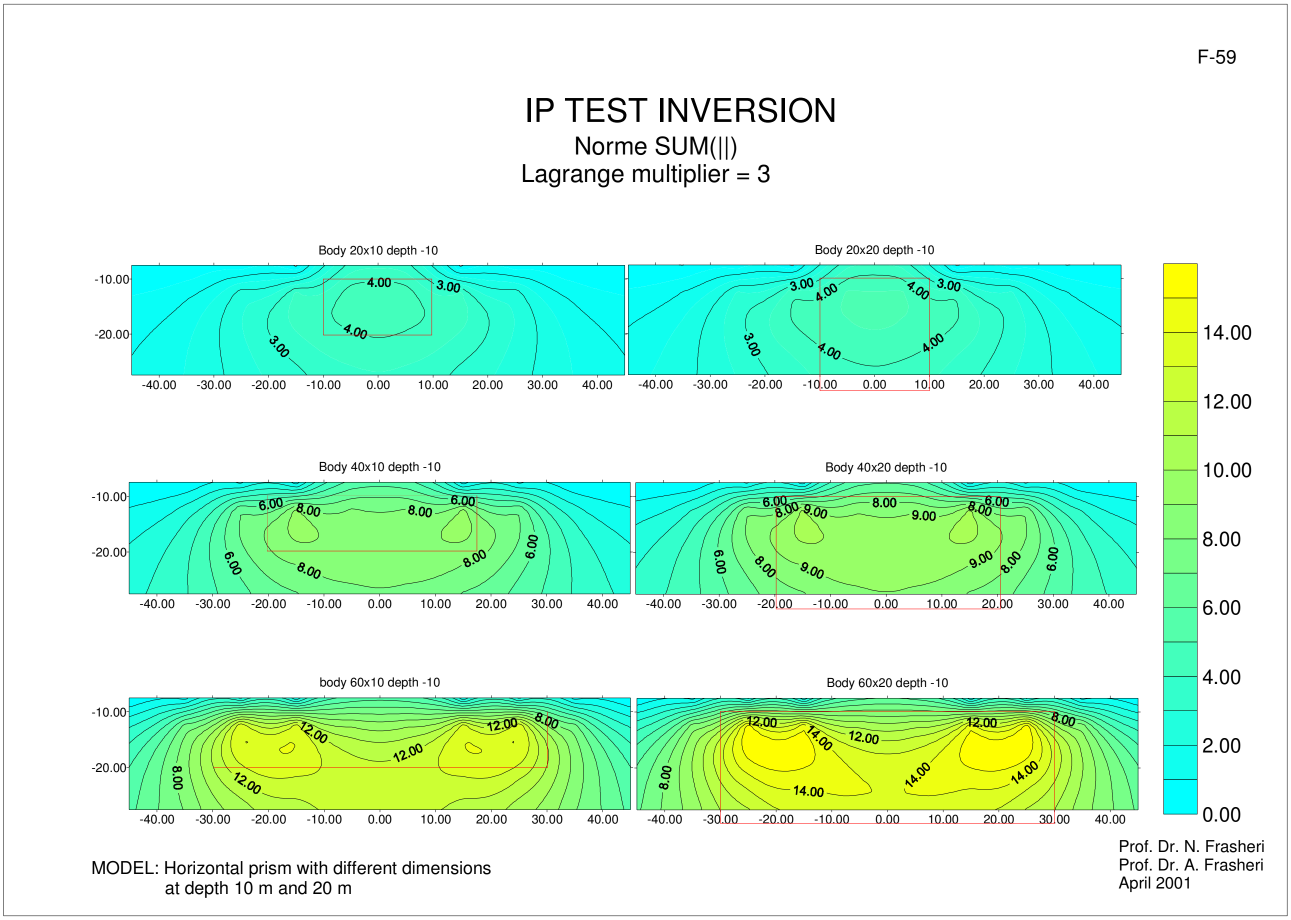

Fig. 27

6. CONCLUSIONS

1. The anomaly configuration in an IP/Resistivity survey with a dipole–dipole array is dependent on the location of the current and potential electrodes in connection to target. In this regard, logistical information about the survey should include the array orientation (left-array or right-array). The position of the array must be shown in plots and pseudosections. During the survey, it is necessary to keep the same orientation of current and receiving dipoles.

2. An accurate interpretation of IP/Resistivity data with dipole-dipole array should consider the information on electrode orientation on the survey line. The same recommendation is valid for the process of inversion interpretation.

3. Physical modeling of IP gives the proof that there are differences between real cases and mathematical models. In sections compiled with data from physical models the anomalies close under the bottom side of targets. In sections of mathematical linear

models IP anomalies remain open in depth, contrary to those of apparent resistivity. It is due to the fact that in used mathematical formulas the IP chargeability is considered as a linear phenomenon in the whole range of variation of polarizing tension.

4. The use for the inversion of formulas based on the linear IP phenomenon implies errors in compilation of sections based on approximation of inversed data. These errors may be comparable with the instability of the inversion itself.

5. To achieve the levels of actual requirements for the quality of IP surveys, it is necessary to well evaluate the non-linear character of IP phenomenon. It would permit a better conception of mathematical basis of IP, as well as a better match with the real situation of the phenomenon in nature. Used with the IP inversion, these new mathematical non-linear equations would permit more exact results as compared with the instability and non-uniqueness of inversion solutions.

6. An effective tool for exploration has been and continues to be ‘Realsection IP’

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DIRECT USE OF GROUND HEAT FOR SPECE HEATING AND COOLING, IN THE LOW ENTHALPY GEOTHERMAL ENERGY AREAS PRESENT A CONTRIBUTION IN COUNTRY ENERGY SYSTEM

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ABSTRACT

In the paper a detailed analyze of the shallow ground heat resources in Albania, in particularly in Korça city, and ways for direct use of this energy concretely for heating in Albania is presented. Direct use of the ground heat by Borehole heat Exchanger-Geothermal Heat Pump for space heating and cooling, was programmed to develop in Albania.

Keywords: Geothermal energy, space heating, geothermal heat pumps, direct use, heat flow,.

1. INTRODUCTION

Large numbers of geothermal energy of high and low enthalpy resources, a lot of mineral water sources represent the base for successfully application of modern technologies in Albania, to achieve economic effectively. There are many thermal springs and wells. Their water has temperatures that reach values of up to 65.5°C.

At present, the thermal waters of some springs and wells are used only for health purposes.

The geothermal situation of low enthalpy in Albania offers three directions for the exploitation of geothermal energy (Frasheri et al. 2003):

Firstly, space heating and cooling
Secondly, integrated and cascade use of geothermal waters energy
Thirdly, greenhouses and aquaculture installations.

Direct use of the environmental friendly geothermal energy must be realized by integrated scheme of geothermal energy-heat pumps and solar energy, and cascade use of this energy.

The most important direction is space heating and cooling. The Earth Heat can be use for space heating and cooling by modern systems Borehole Heat Exchanger-Geothermal Heat Pumps.

In the paper is presented a detailed analyse of the shallow ground heat resources in Albania, in particularly in Korça city, and ways for direct use of this energy concretely for heating in Albania.

2. PRESENTATION OF THE PROBLEM

The energy crisis prevailing in the Albania, the increased demand in energy for heating and cooling of premises, the gradual implementation of European standards of premises' heating, are all decisive factors raising the awareness in order to contribute in finding optimal solutions to this critical situation. Actually, the electric energy consummation for heating is 1 375 GWh/year, or 23.8 % of the total electric energy production in Albania (Fig. 1) (National Agency of Energy, Tirana, 2003). The situation becomes more problematic because the use of natural gas for heating emits large quantities of CO_2 in the atmosphere.

In the developed countries such as the Member States of the European Union, in the United States, Japan etc., particular attention is given to the use of renewable energies, among them the geothermal energy (Lund. J.W., et al. 2005, Rybach L., et al, 2005). The Earth's heat is a great source of energy, renewable and friendly to the environment. Direct use of the ground heat by Borehole heat Exchanger-Geothermal Heat Pump represents a modern system for space heating and cooling (Lund J.W., et al. 2005, Rybach L., et al. 2000, 2004).

Alike elsewhere in the world, in Albania the subsurface ground layers contain heat. This energy can be successfully exploited in heating the public premises (offices, hospitals, libraries, theatres, airports etc.) as well as private premises (houses and apartment buildings), using the modern systems of Borehole-Heat Exchanger-Geothermal Heat Pumps.

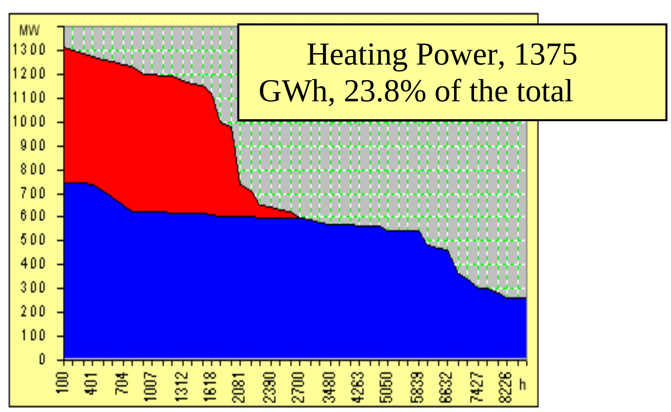

Fig. 1. Yearly electric energy consumption without and with space heating, for 1999 y. (National Agency of Energy).

Two types of shallow heat sources exist: ground heat and underground waters heat. Consequently two kind of technology is possible to applied:

Firstly, ground-source and Borehole heat Exchanger-Geothermal Heat Pump or ground-couplet (closed loop),

Secondly: underground water system – Geothermal Heat Pump (open loop).

Ground coupling is used where insufficient well water is available or where quality of the well water is a problem. Multiple Heat Exchangers are installed in large public premises.

Actually, in Albania have set up only first four installations of geothermal heat pumps systems. In order to develop direct use of this renewable geothermal energy and environmental friendly ground heat for space heating and cooling in Albania, we have introduced the idea of building a demonstrative installation for heating and cooling purposes of the important public building in Tirana and in other Albanian cities, ex. University Campus, Hospital, Secondary School, etc. (Frasheri et al. 2003, Frashëri A. 2008, Frashëri A. et. al. 2008). It will be of great professional satisfaction if this proposal will find application. It will contribute in solving the problematic issue of heating and cooling of premises in Albania.

The implementation of this project contributes in raising the awareness of the public administration, of the business and scientific communities, to make use of this economically optimal solution for heating and cooling of premises. The public administration should introduce the necessary tools and incentives for enabling the entering into the market of such modern and environmentally friendly systems. The business community should have in consideration and invest in installation of these Borehole-Heat Exchanger-Geothermal Heat Pumps, making way for new businesses. The universities should teach about these modern systems and insists on their applicability.

3. A WORLDWIDE EXPERIENCE

In 26 European countries and United States there are installed 570 000 installations BHE-HP, with a power of 12 KW each, for heating and cooling of houses, but also there are thousands installations with a power of up to 500-1500 KW for heating of institutions and of apartment buildings (Lund J. W., et al. 2005, Rybach L., et al. 2005). In Germany there are 50 000 installations. Switzerland is a typical example with 21 000 installations, with a pump power from 19-40 KW, which exploits the heat of nearsurface earth layers with a temperature of 10oC. In Switzerland, in 1980 the production of geothermal energy by these systems was 70 GWh, in 1999 it is increased up to 365 GWh. Japan (Japan Times, Jan. 21, 2003), using the geothermal energy of subsurface ground layers saves up to 40% of the total energy. The expenses necessary to carry out this project will be paid within 10 years. Two thirds of the building costs, valued up to 10 million yen for the government and local authorities support each installation.

Ground-couplet systems have been used in Northern Europe for many years. Actually, these modern systems in use, highly effective and with low consume of electric energy, technologically advanced and environmental friendly, are gaining huge popularity (Rybach L. et al, 2000).

Borehole-Heat Exchanger-Geothermal Heat Pump systems are developed even though has a construction cost 30-40 % higher than the conventional heating by gas. There are several reasons for this:

Economical considerations. Actually, the cost of installing the Borehole-Heat Exchanger-Geothermal Heat Pump is higher than the conventional fuel installations. Nonetheless, the annual cost of “fuel” of the Borehole-Heat Exchanger-Geothermal Heat Pump (Electric energy for the heat pump and circulating pump) are considerably lower than the fuel of the conventional heating by gas. ***For the coefficient of performance 3, is saved up to 66% of the electrical energy.*** Consequently, the payback of the Borehole-Heat Exchanger-Geothermal Heat Pump system is shorter than the durability of using the other heating system.

Environmental considerations. Borehole-Heat Exchanger-Geothermal Heat Pump is an environmental system that does not emits CO2 (“greenhouse effect”), therefore the proprietor avoid paying the tax on emittance of CO2 gas, which is under discussion in the countries of the European Community.

Governmental support. The Japanese government has invested 200 USD for every kW of the Pump of Geothermal Energy, with an upper limit of 5 200 USD.

4. GROUND GEOTHERMAL ENERGY RESOURCES IN ALBANIA

Heat quantity, temperature at Earth surface, and geothermal gradient in shallow geological section, are conditioned by geographical location, geomorphological conditions (Earth surface dip and position in relation by Sun), ground and bedrocks lithology, specific heat and humidity, season and weather. According to the multy annual meteorological surveys result that in average is 140,000 calory.cm^{-2} heat from solar radiation of the ground during the summer at the plane areas of the Albania. Heat quantity reaches 120,000 calory.cm^{-2} at northeaster mountains regions [Gjoka L., 1990].

Thermal field distribution and geothermal gradient values in the ground at shallow geological section are conditioned that at the depth 100m the temperatures reaches from 16oC up to 18.8^{o}C at plane areas in the Ionian tectonic zone and in Peri Adriatic Depression (Fig. 2). The areas with a temperature between 18 °C and 19 °C are located at Kolonjë-Divjakë-Kryevidh, Vlorë and Sarandë-Delvinë zones (Frashëri A., et al. 2004, 2008).

There are some particularities in the distribution of the temperature at the depth 100m:

Temperature in subsurface ground at littoral area:

Minimal temperature is 16.60 ^{O}C

Maximal temperature is 18.80 ^{O}C

Average temperature is 17.80 ^{o}C

Temperature in subsurface ground at western plane-hilly area:
Minimal temperature is 17.15 ^{o}C
Maximal Temperature is 18.41 ^{o}C
Average Temperature is 18.0 ^{o}C

Temperature in subsurface ground at hilly-mountains regions:
Minimal temperature is 6.70 ^{o}C
Maximal temperature is 18.60 ^{o}C
Average temperature is 14.75 ^{o}C

In plane area of Albania, example in the Tirana field (Rinasi), the temperature is 15.5 ^{o}C, up to logging depth 31 m, in the Quaternary deposits (Fig. 3) (Frashëri et al. 2003). According to the well-known data, the layers at the depth from 0-8-10 m have a temperature, which is conditioned by solar radiation energy. During the winter, the temperature is lower than during the summer. Below, the ground temperature is constant during the year, because don't have the influence from solar radiation. Depth limit of the solar radiation influence zone is not unique. Lateral changes up to 0.5 ^{o}C are observed in the 500m distances, for the same time. These lateral changes are conditioned by lithology of the Quaternary loose deposits. The belt of the constant temperature continues up to the depth 50 m in the mountain regions of the Albania.

According to the analyse of the geothermal regime of the shallow geological section is concluded that is possible to use the ground heat for the space heating and cooling, applied modern Borehole Heat exchanger – geothermal Heat Pump.

Ground geothermal energy has heated the underground water reservoir (Fig. 3,4). In Tirana underground water basin are following temperatures:

Water temperature of the Quaternary gravel layer is 14-15 ^{o}C,

Water temperature of the Quaternary sandstone layers is 15-16^{o}C

Consequently, concluded that water of the Tirana underground basin can be a heat source for the geothermal pumps.

5. ECONOMIC EVALUATION OF THE PROPOSED SCHEME HEATING OF UNIVERSITY "FAN NOLI", KORÇA CITY

Total heated surface, for three-floors:1200 m^{2}
Heating system: Borehole-Heat Pump-Radiators
Heating capacity 134 KW
Heating period 1836 hours

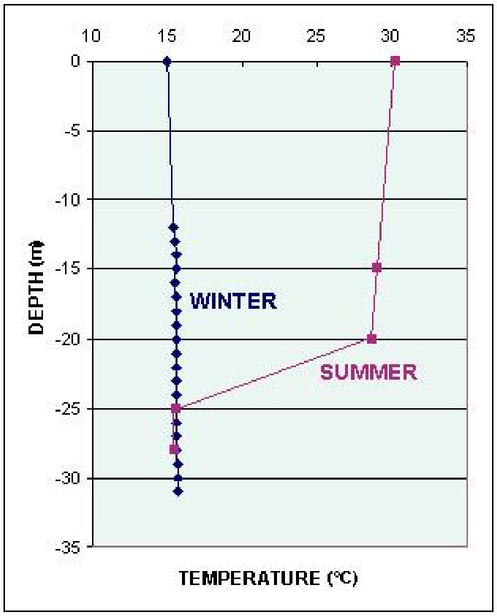

Fig. 3. Thermolog of the Rinasi borehole

Heating system, there are analyzed three variants:
a) Borehole-Geothermal Heat Pump
b) Borehole-Heat Exchanger-Geothermal Heat Pump
b) Oil Fired Boiler

Installed cost for:
a) Borehole-Geothermal Heat Pump 58.101Euro
b) Borehole-Heat Exchanger-Geothermal Heat Pump 121.123
c) Oil Fired Boiler 16.579

Specific Installed cost for:
a) Borehole-Geothermal Heat Pump 59.3 Euro/m^{2}
b) Borehole-Heat Exchanger-Geothermal Heat Pump 109.3
b) Oil Fired Boiler 15.6

Yearly expenses for the oil for boiler and electric Energy for geothermal heat pumps:

- Oil for boiler 39.960 Euro
- Electric energy for Borehole-Heat Exchanger-Geothermal heat pump system 26.970
- Electric energy for Borehole-Geothermal heat pump system 24.814

Payback period for the installed cost for:

- Payback period of Borehole-Heat Exchanger Geothermal heat pump system 2,2 years
- Payback period of Borehole-Geothermal heat pump system 4,9

Installed cost can be covered only by expenses savings for boiler fuel.

In fig 5 is presented the graphic of the installed costs and yearly expenses for the oil and electric energy for the geothermal heat pumps for space heating for different heating systems.

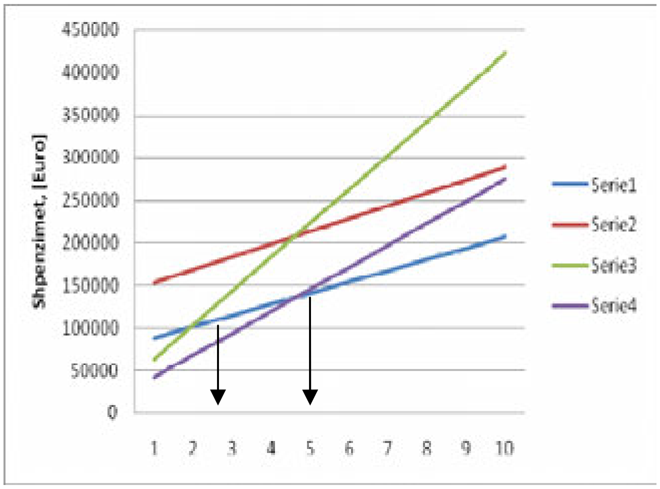

Fig. 5. Installed costs and yearly expenses for fuell and electric energy for the geothermal heat pumps for space heating for different heating systems.
Legend: Serie 1: Borehole-Geothermal Heat Pump system , Serie 2: Borehole-Heat Exchanger Geothermal Heat Pump system ; Serie 3: Boiler system, oil price 1,2 Euro/liter; Serie 4: Boiler system, oil price 0.8 Euro/liter.

Fig. 6 shows the cumulative yearly expenses for the fuel and electric energy for heating system works.

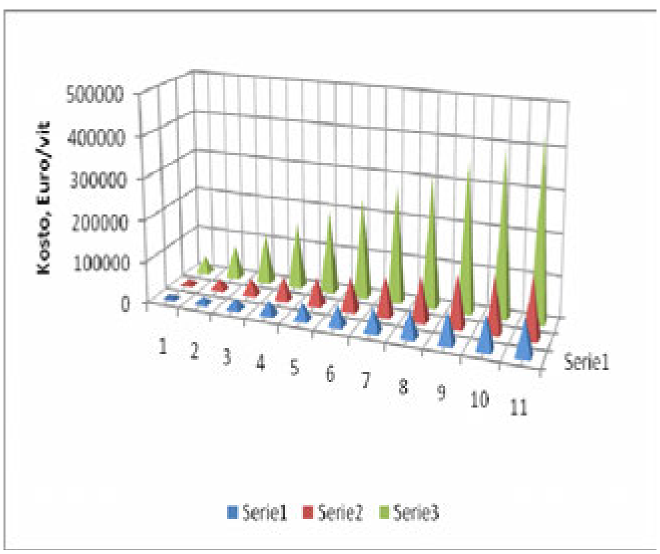

Fig. 6. Cumulative yearly expenses for the oil and electric energy for the geothermal heat pumps for space heating for different heating systems (in Euro).
Legend: Serie 1: Borehole-Geothermal Heat Pump system , Serie 2: Borehole-Heat Exchanger Geothermal Heat Pump system ; Serie 3: Boiler system.

In the fig. 7 is presented the plots of the differences of yearly cumulative expenses for the fuel and electric energy for the geothermal heat pumps for space heating and installation costs for different heating systems.

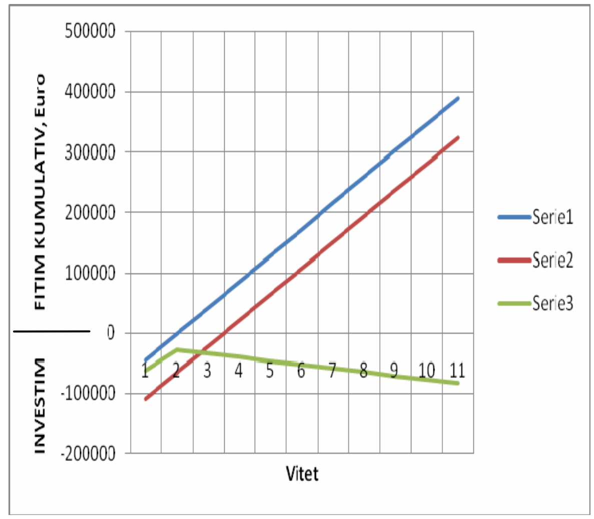

Fig. 7- The plots of the differences of yearly cumulative expenses for fuel and electric energy for the geothermal heat pumps for space heating and installation costs for different heating systems (in Euro).
Legend: Serie 1: Borehole-Geothermal Heat Pump system , Serie 2: Borehole-Heat Exchanger Geothermal Heat Pump system ; Serie 3: Boiler system.

Price of heating energy for the geothermal system results 3,45 Lek/kWh (0,0265 Euro/kWh) and 5,81 Lek/kWh (0,0446 Euro/kWh) respectively for Borehole-Geothermal Heat Pump system , Serie 2: Borehole-Heat Exchanger Geothermal Heat Pump system; in the same time for the boiler system the price results 16,9 Lek/kWh (0,13 Euro/kWh), consequently 4,9-2,9 time more expenses (fig. 8)

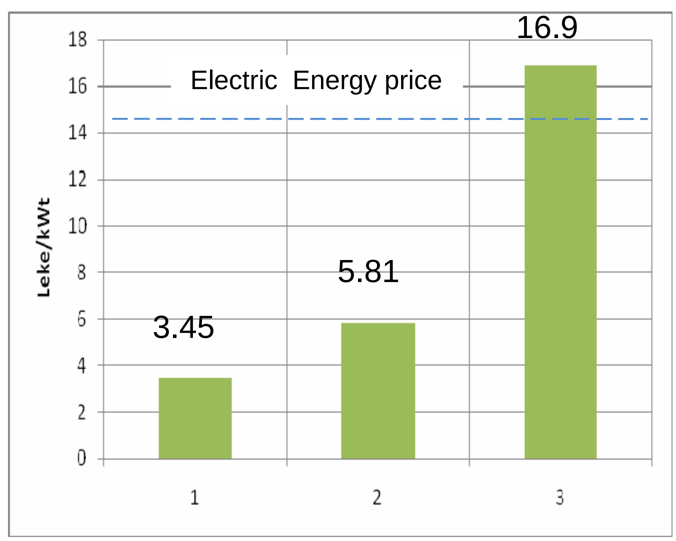

Fig. 8. Cost in Lek/kWh for space heating of the University of Korça building, for the payback period.

Legend: Serie 1: Borehole-Geothermal heat pump system , Serie 2: Borehole-Heat Exchanger Geothermal heat pump system ; Serie 3: Boiler system.

According to this analyze and graphics of the fig. 5-8, results that geothermal heating and cooling system is more economic system that boiler system.

6. CONCLUSIONS

a) The heating problem and its economic solution is an important task, taking into consideration the current severe energetic crises. One of the ways out is the use of geothermal energy. In Albania there are many high-rise building, which are still projected to include oil or gas fired boiler systems, as well as with air conditioning units. Air conditioning units heat all public institutions. The hospitals, dorms, hotels are heated by oil and gas fired boilers. It is the ripe time to move out of such practices, which do not provide for long term sustainable solutions to the heating and cooling problems in Albania.

b) Direct use of the geothermal energy for space heating/cooling can be contribute to improve country energy balance.

c) It is the right time to introduce systems using renewable energy shallow sources such as the geothermal energy: .

d) Geothermal space heating/cooling systems represent not only high economical efficiency but are environmental friendly.

Based on these conclusions, in the condition of the intensive building's construction in Albania and energetic crisis, are important two recommendations:

Firstly, the geothermal systems must have the priority for space heating/cooling of the new public and private buildings (industrial, and residential, etc.),

Secondly, the geothermal systems must have the priority during the re-construction of the heating/cooling systems of the hospitals, schools, dorms, hotels, etc., which are heated by oil and gas fired boilers.

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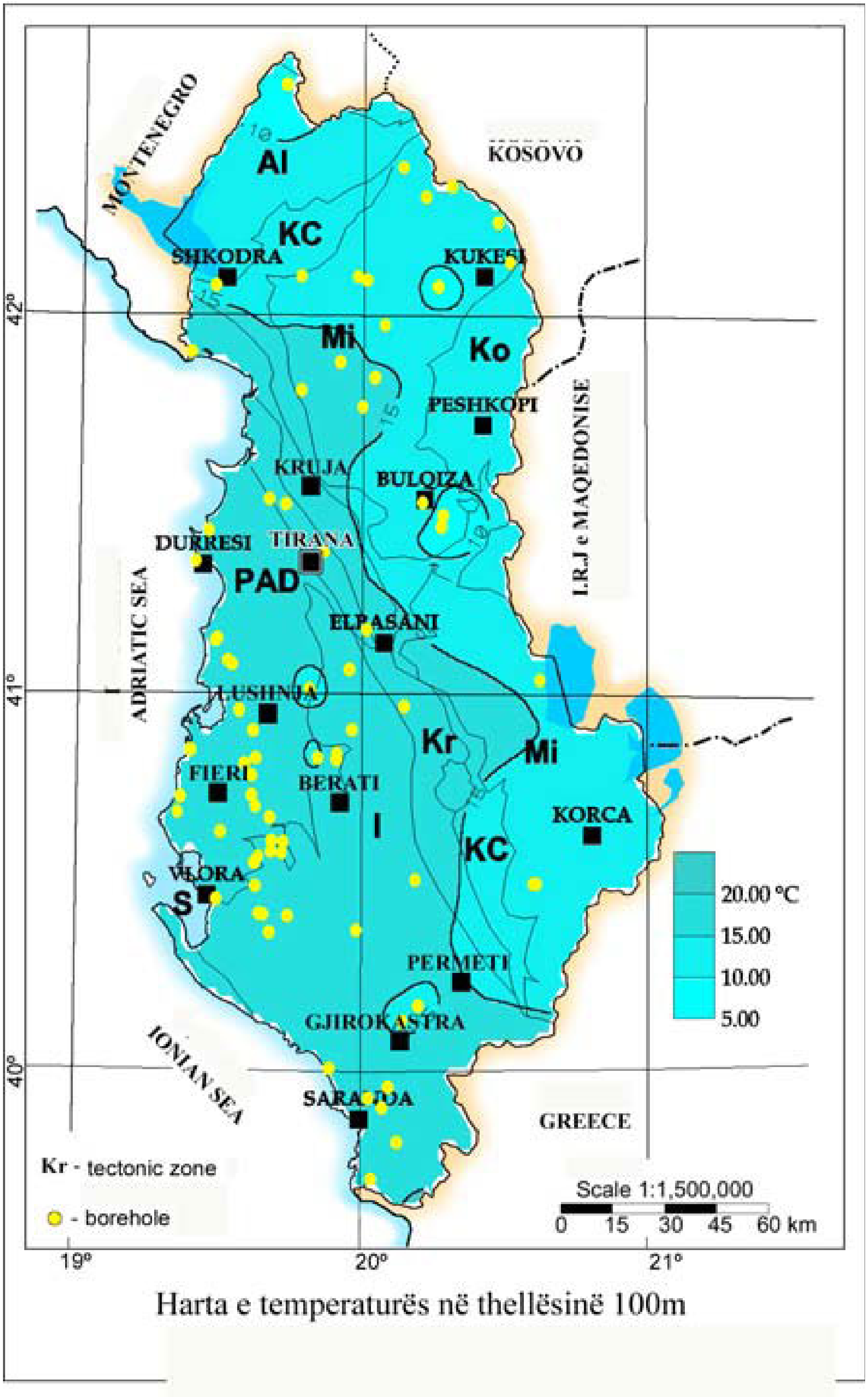

Fig. 2. Temperature map of Albania, at the depth 100 m.

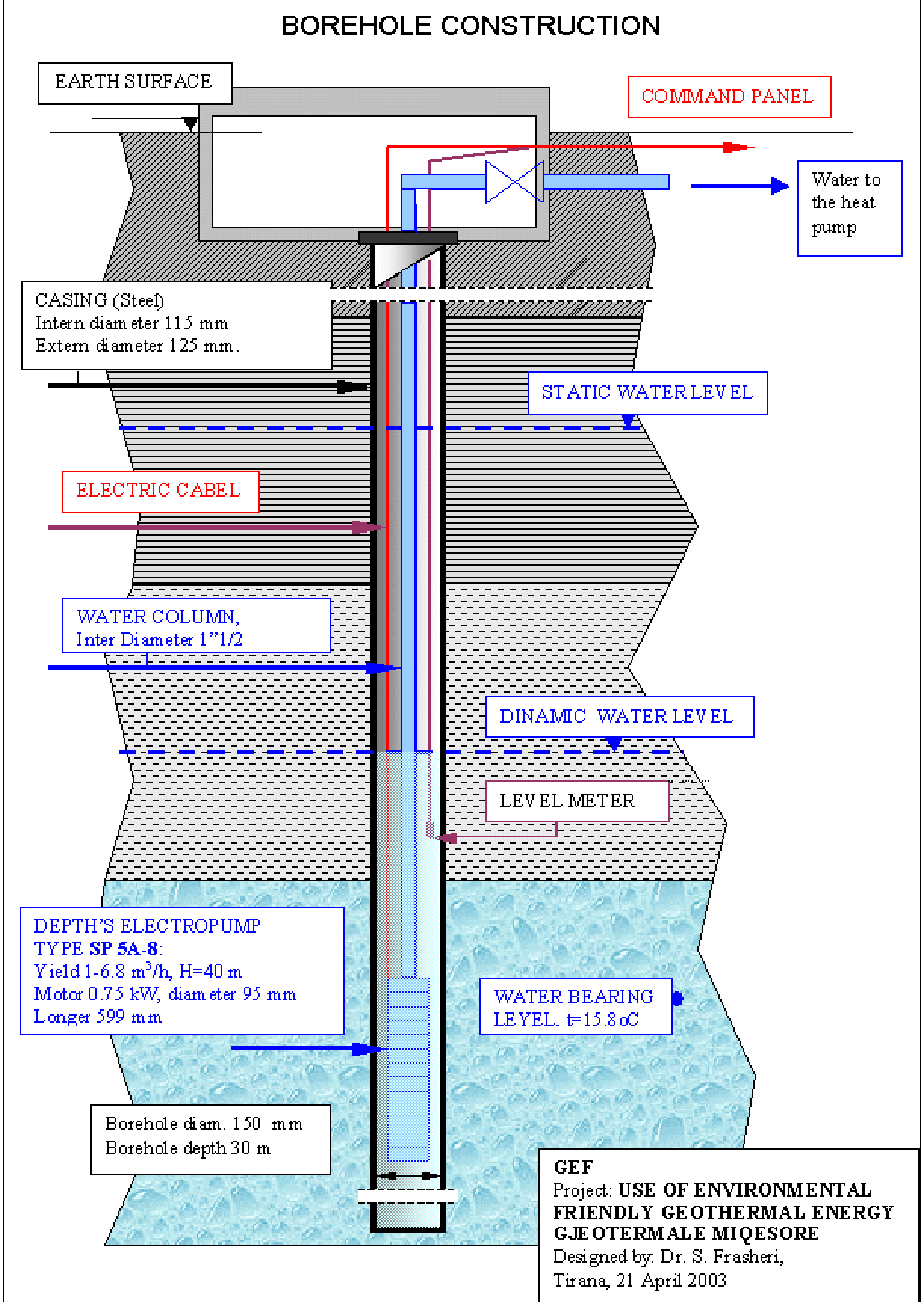

Fig. 4. Shallow Heat Source of Quaternary aquifer in Tirana Field region and borehole construction for water pumping to the Geothermal Heat Pump.

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GEOTHERMAL ENERGY SYSTEMS IN ALBANIA

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ABSTRACT

Paper represents a summary of the important results of the Monograph "Atlas of geothermal resources in Albania" (2004), and "Platform for integrated and cascade use of geothermal energy of low enthalpy in the framework of energetic balance of Albania" (2008). Atlas is publication of the results of studies, which were performed in the framework of the National Program for Research and Developing- Natural Resources, 2003-2005, project of the. Committee for Sciences and Technology of Albania and agreement between the Faculty of Geology and Mining, and the Geophysical Institute, Czech Acad. Sci., Prague, European Commission- International Heat Flow Commission and UNDP-GEF/SGP Tirana Office projects (1989-2005) [Frashëri A. 1992, Frashëri A. et al. 1994, 1995, 1996, 2001, 2003]. Platform is prepared in the framework of the National Program for Research and Development, "Water and Energy" 2007-2009. Has been published a monograph: "Space Heating/Cooling Borehole-Vertical Heat Exchanger-Heat Pump System"(2008).

In Albania there are many thermal water springs and wells of low enthalpy, with a temperature of up to 65.5°C, which indicates that there are possibilities for direct use of the geothermal energy. In Albania the new technologies of direct use of geothermal energy are either partly developed or remain still untouched. Integrated and cascade use of geothermal energy of low enthalpy will be represent an important direction for profitable investment. Exploitation of geothermal energy will have a direct impact in the development of the regions, by increasing their per capita income and at the same time ameliorating the standard of living of the people.

Keywords: Geothermal energy, direct use, heat flow,.

1. INTRODUCTION

In Albania, rich in geothermal resources of low enthalpy and mineral waters, new technologies of direct use of geothermal energy are still undeveloped. Large numbers of geothermal energy of low enthalpy resources, a lot of mineral water sources and some CO_2 gas reservoirs represent the base for a successful application of modern technologies in Albania, to achieve economic effectiveness and success of complex direct use.

At the present, many geothermal, hydrogeological, hydrochemical, biological and medical investigations and studies on thermal and mineral water resources are ongoing in Albania. The results of the geothermal studies carried out in Albania are presented in maps and geothermal sections. Temperature maps have been drawn for different levels up to 3000m depth. Geothermal gradient, heat flow density and geothermal resources maps have also been drawn. The natural springs with thermal waters and the geological structures with high water temperature have also been mapped. Generally, these investigations and studies are separated each from the other. These studies and evaluations are necessary to well know at a regional scale the thermal and mineral water resources potential and geothermal market of the Albania.

According to the results of these new studies, the evaluation of the perspective level of the best areas in country will be necessary. After such evaluation is possible to start investments in these areas. Integrated exploitation and cascade direct use of the geothermal energy will be realized by an integrated scheme of geothermal energy, heat pumps and solar energy. This scheme gives an environmental benefit by using renewable energies (geothermal and solar energy), new technologies (heat pumps) and energy savings (cascade scheme). Cascade scheme should be used to fulfill the thermal energy demand for the selected area in order to get the maximum benefit from geothermal energy and the minimum energy supply from heat pumps.

Actually in Albania the study of the possibilities of exploitation of the geothermal energy has begun. The aims of the project are to examine, demonstrate and disseminate the positive technical and financial aspects of transfer and utilization of innovative geothermal energy technologies in Albania.

2. GEOLOGY BEACKGROUND

The Albanides represent the main geological structures that lie on the territory of Albania. They are located between the Dinarides in the north and the Helenides in the south, and together they form the Dinaric Branch of Mediterranean Alpine Belt. Albanides are divided in two big peleogeographical zones: the Inner Albanides and the External Albanides. Korabi, Mirdita (ophiolitic belt), presents the Inner Albanides and Gashi zones. The Alps, the Krasta-Cukali, the Kruja, the Ionian zone, the Sazani zone and the Pre-Adriatic Depression present the External Albanides. Depression as a part of Albanian Sedimentary Basin, continued towards the shelf of the Adriatic Sea. The geological cross-section of Albanian Sedimentary Basin is about 15 km thick and it continues also in the Adriatic Sea Shelf.

The structures of the Albanides are typically Alpine ones. The SSE-NNW directions represent their general strike. The structures are asymmetrical and have a western vengeance. Recumbent, overthrusted and overtwisted structures are found, too. Generally, their western flanks are affected by disjunctive tectonic.

3. METHODS AND STUDY AREA

Geothermal studies carried out in Albania are oriented toward the study of the distribution of the geothermal field and the natural thermal water springs and wells. Geothermal studies were extended all over the country territory.

The temperatures have been measured and the geothermal gradient and the heat flow density at different depths have also been calculated (Frasheri et al. 1995). Temperature measurements were carried out both in 145 deep wells, in boreholes and in mines, at different hypsometric levels. The temperature in the wells was recorded at regular intervals. It was measured by means of resistance and thermistor thermometers. The average absolute measurement error was 0.3°C. The measurements were carried out in a steady-state regime of the wells filled with mud or water. The recorded data were processed using the trend analysis of first and second degrees. The chemical composition of the waters was found. The output of the springs and wells and their hydrogeology was evaluated.

4. RESULTS

4.1.Geothermal Regime

The Geothermal Regime of the Albanides is conditioned by tectonics of the region, lithology of geological section, local thermal properties of the rocks and geological location (Frasheri A. 1992, Frasheri et al. 1994, 1995, 2004).

4.1.1. Temperature

The geothermal field is characterized by a relatively low value of temperature. The temperature at 100 meters depth vary from less than 10 to almost 20°C, with lowest values in the mountain regions Fig. 1). The temperature is 71.8oC at the depth 3000 meters (Fig. 2), and 105.8°C at 6000 meters depth, in the central part of the Peri-Adriatic Depression. The isotherm runs parallel the Albanides strike (Fig. 2). Going deeper and deeper the zones of highest temperature move from southeast to northwest, towards the center of the Peri-Adriatic Depression and even further towards the northwestern coast. The temperatures in ophiolitic belt are higher than in sedimentary basin, at the same depth.

4.1.2. Geothermal Gradient

In the External Albanides the geothermal gradient is relatively higher. The geothermal gradient displays the highest value of about 21.3 $mK.m^{-1}$ in the Pliocene clay section in the centre of Peri-Adriatic Depression. The largest gradients are detected in the anticline molasses structures of the center of Pre-Adriatic Depression. The gradient decreases about 10-29% where the core of anticlines in Ionic zone contains limestone. The lowest values of 7-11 $mK.m^{-1}$ of the gradient are observed in the deep synclinal belts of Ionic and Kruja tectonic zones.

In the ophiolitic belt of the Mirdita tectonic zone, the geothermal gradient values increase up to 36 $mK.m^{-1}$ at northeastern and southeastern part of the Albania.

4.1.3. Heat Flow Density:

Regional pattern of heat flow density in Albanian territory is presented in the Heat Flow (Fig. 3) Map. There are observed two particularities of the scattering of the thermal field in Albanides:

Firstly, maximal value of the heat flow is equal to 42 mW/m^2 in the center of Peri-Adriatic Depression of External Albanides. The 30 mW^{-2} value isotherm is open towards the Adriatic Sea Shelf. These phenomena have taken place owing to the great thickness of sedimentary crust, mainly carbonatic one in this zone.

Secondly, in the ophiolitic belt at eastern part of Albania, the heat flow density values are up to 60 mW/m^2. The contours of Heat Flow Density give a clear configuration of ophiolitic belt. Radiogene heat generation of the ophiolites is very low. In these conditions, increasing of the heat flow in the ophiolitic belt, is linked with heat flow transmitting from the depth. The granites of the crystalline basement, with the radiogenic heat generation, represent the heat source.

4.2. Geothermal energy resources in Albania

Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters with a temperatures that reach values of up to 65.5°C are sulfate, sulfide, methane, and iodinate-bromide types (Frasheri A. et al. 1996, 2004) (Tab. 1, Fig.4). In many deep oil and gas wells there are thermal water fountain outputs with a temperature that varies from 32 to 65.5°C (table 1, Fig. 4).

Albanian geothermal areas have different geologic and thermo-hydrogeological features. Thermal sources are located in three geothermal zones (fig. 4):

Kruja geothermal zone represents a zone with bigness geothermal resources. Kruja zone has a length of 180 km. Kruja Geothermal Zone is extended from Adriatic Sea at North and continues in South-Easter area of Albania and in Konitza area in Greece. Photo 1 shows Langarica - Permet thermal springs at southern Albania. Identified resources in carbonate reservoirs in Albanian side are $5.9x10^8$-$5.1x10^9$ GJ. The most important resources, explored until now, are located in the Northern half of Kruja Geothermal Area, from Llixha-Elbasan in the South to Ishmi, in the North of Tirana. The values of specific reserves vary between 38.5-39.63 GJ/m^2.

Kruja geothermal area represents an anticline structure chain with carbonatic core of Cretaceous-Eocene age. They are covered with Eocenic- Oligocenic flysch. Anticlinals are linear with as length of 20-30 km. They are assymmetric and their western flanks are separated from disjunctive tectonics. Geothermal aquifer is represented by a karstified neritic carbonatic formation with numerous fissures and microfissures.

Thermal water sources and wells in Albania
Tab. 1

Type of the source	Location	Temperature, (°C)	TDS, (mg/l)	Yield, l/sec
Natural Spring	Llixha Elbasan, Peshkopi, Krane (Sarande), Langaric (Permet), Shupal (Tiranë), Sarandoporo (Leskovik), Postenan (Leskovik) Tërvoll (Gramsh), Mamurras (Tiranë).	21-60	0.3-26	10-40
Deep wells	Peri Adriatic Depression and in the Kruja tectonic zone	29.3-65.5	1-19.3	0.9-18

In the Ishmi area, Ishmi 1-b well has been drilled in 1994. It is situated in the top part of the limestone structure. It is located 20 km North- West of Tirana, in the plain area, near “Mother Theresa” Tirana airport. It meets limestone at 1300m of depth and goes through a carbonatic coupe of 1016 m thickness.

Kozani 8 well has been drilled in 1989 (Photo 1). It is situated 35 km South- East of Tirana and 8 km North- West of Elbasani. It is situated on hills close to Tirana- Elbasani national road. It meets limestone at 1810m of depth and goes 10m deep in them.

Since the end of the drilling to this day hot water continues to fountain from Ishmi 1-b and Kozani 8 wells.

Elbasani Llixha watering place is about 12 km South of Elbasani. There are seven spring groups that extend like a belt with 320^{o} azimuth. All of them are connected with a the main regional disjunctive tectonics of Kruja zone. Thermal waters flow out through the contact of conglomerate layer with calcolistolith. In this area too, the reservoir is represented by the Llixha limestone structure. These springs have been known before Second World War.

Surface water temperatures in the Tirana-Elbasani zone vary from 60° to 65.5°. In the aquifer top in the well trunk of Kozani 8 temperature is 80°C. Hot water is mineralized, with a general mineralization of 4.6-19.3 g/l. Elbasani Nosi Llixha water has the following formula:

$$H_2S_{0.403}M_{7.1}\frac{Cl_{59}SO_{38}^{4}}{Na_{46}Ca_{35}}$$

Photo 2 shows the Langaric-Permet geothermal water-place .

Peshkopia gjeotermal zone is situated in the Northeast of Albania. Two kilometers East of Peshkopia some thermal springs are situated very close to each other. These thermal springs flow out on Banja river slope. These springs are linked with the disjunctive tectonic seismic-active zone Ohrid Lake-Debar, at periphery of gypsum diapir of Triassic age, that has penetrated Eocenic flysch, which surround it like a ring. The occurrence of thermal waters is connected with the low circulation zone always under water pressure. They are of sulfate-calcium type, with a mineralization of up to 4.4 g/l, containing 50 mg/l H_2S. Their chemical formula is:

$$H_2S_{0.0495}M_{4.4}\frac{SO_{56}^{4}}{Ca_{65}}$$

Yield of some of the springs goes up to 14 l/sec. Water temperature is 43.5 °C.

Water temperature and big yield, stability, and also aquifer temperature of Peshkopia Geothermal Area similar are with those of Kruja Geothermal Area. For this reason geothermal resources of Peshkopia Area have been estimated to be similar to those of Tirana- Elbasani area.

Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs.

5. DIRECTIONS FOR THE DIRECT USE OF GEOTHERMAL ENERGY OF LOW ENTHALPY IN ALBANIA

The geothermal situation of low enthalpy in Albania offers three possibilities for the direct use of geothermal waters energy. Geothermal energy exploitation must be realized by integrated scheme of geothermal energy, heat pumps and solar energy, and cascade use of this energy (Frashëri A. 2001, Frashëri A. et al. 2003, 2004, 2008).

Firstly, the Ground Heat can be use for space heating and cooling by Borehole Heat Exchanger-Geothermal Heat Pumps modern systems.

Secondly, thermal sources of low enthalpy and of maximal temperature up to 65.5°C.

Thermal waters of springs and wells may be used in several ways:

1. Modern SPA clinics for treatment of different diseases and hotels, with thermal pools, for development of eco-tourism. Such centers may attract a lot of clients not only from Albania, because the good curative properties of waters and springs are situated at nice places, near seaside, Gjinari mountain or Ohrid Lake pearl.

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well, near of Saint Vladimir Monastery at Elbasani, have the possibilities for modern complex exploitation. Ishmi 1/b

geothermal well is located in beautiful Tirana field, near of Mother Theresa- Tirana Airport, near of the Adriatic coastline and Kruja - Skenderbeg Mountain.

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3. From thermal mineral waters it is possible to extract very useful chemical microelements as iodine, bromine, chlorine etc. and other natural salts, so necessary for preparation of pomades for the treatment of many skin diseases as well as for beauty treatments. From these waters it is possible to extract sulphidric and carbonic gas.

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Consequently, the sources of low enthalpy geothermal energy in Albania, which are at the same time the sources of multi-element mineral waters, they represent the basis for a successful use of modern technologies for a *complex and cascade exploitation* of this environmental friendly renewable energy, achieving a economical effectiveness. Such developments are useful also for the creation of new working places and improvement of the level of life for local communities near thermal sources.

6. CONCLUSIONS

1. Albania has geothermal energy resources, which can be direct use as alternative, environmental friendly energy.

2. Resources of the geothermal energy in Albania are;
   a) Natural springs and deep wells with thermal water, of a temperature up to 65.5°C.
   b) Heat of subsurface ground, with an average temperature of 16.4°C and depth Earth Heat Flow.

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7. ACKNOWLEDGMENTS

The authors express their thanks also to their colleagues of the Geothermal Team at the Faculty of Geology and Mining of the Polytechnic University of Tirana and of Geophysical Institute at Academy of Sciences of the Czech Republic in Prague, for their scientific collaboration and help in our studies of geothermal energy.

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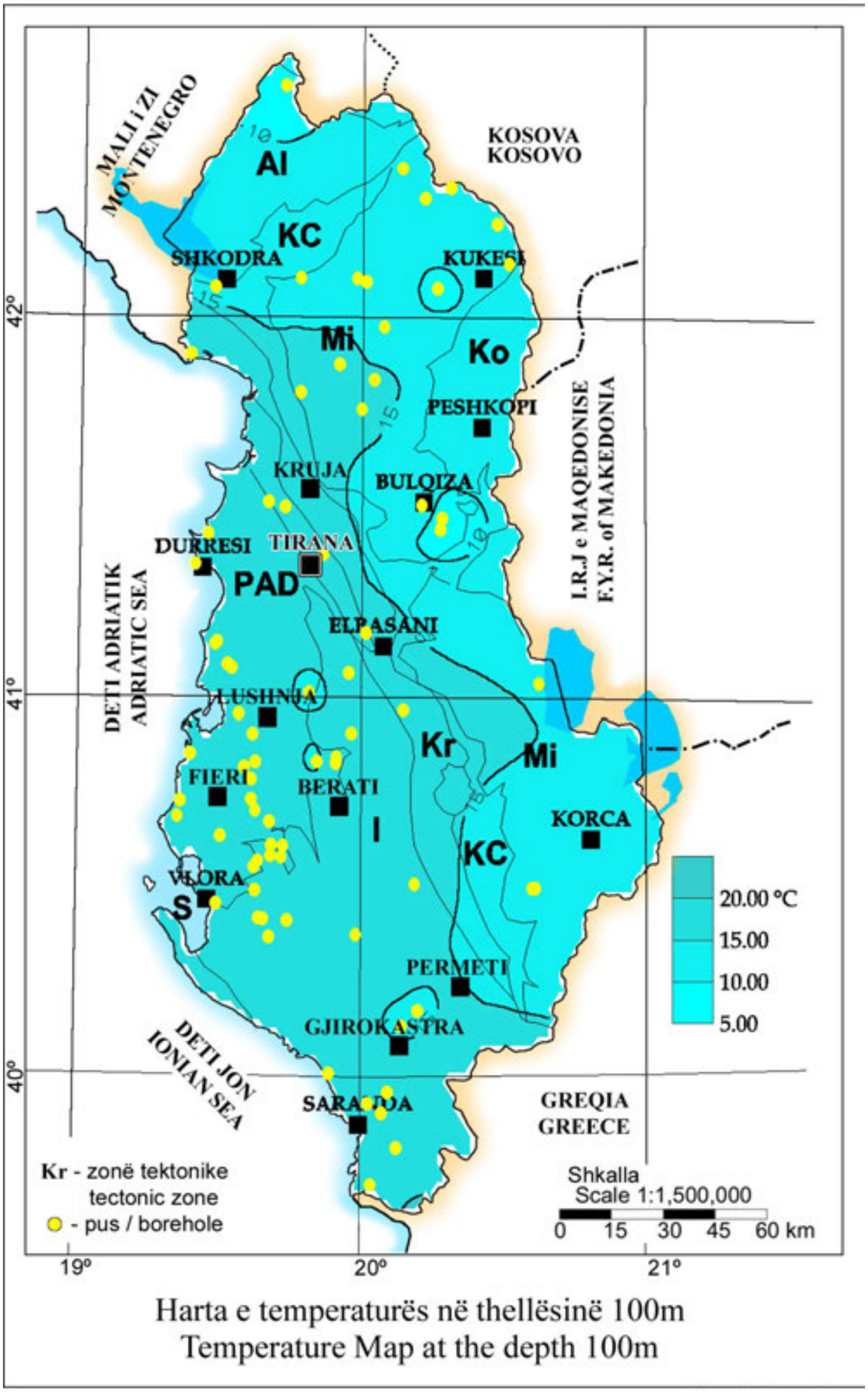
Photo 1. Geothermal deep well Kozani - 8

Photo 1. Langarica-Permeti thermal water springs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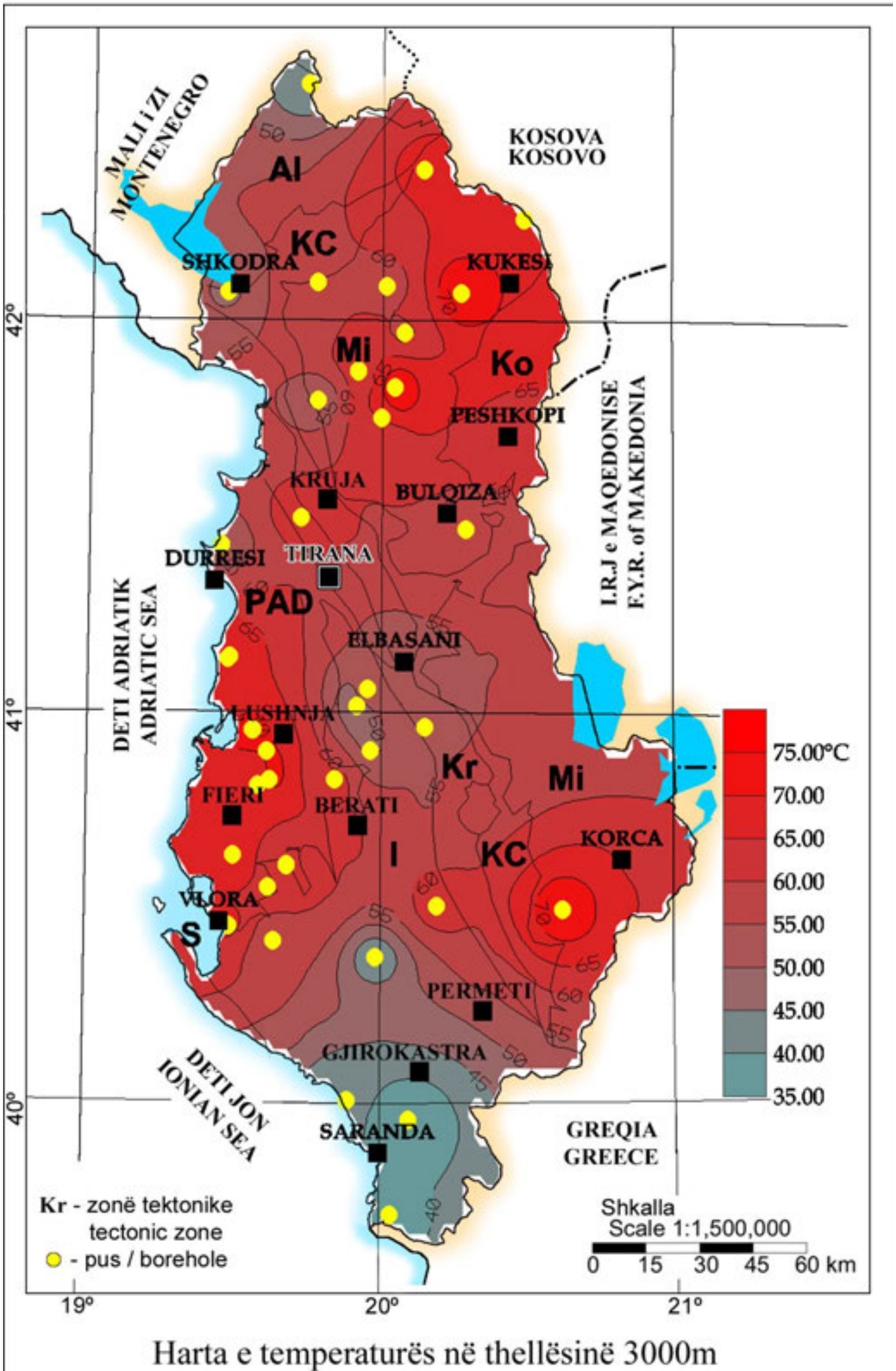
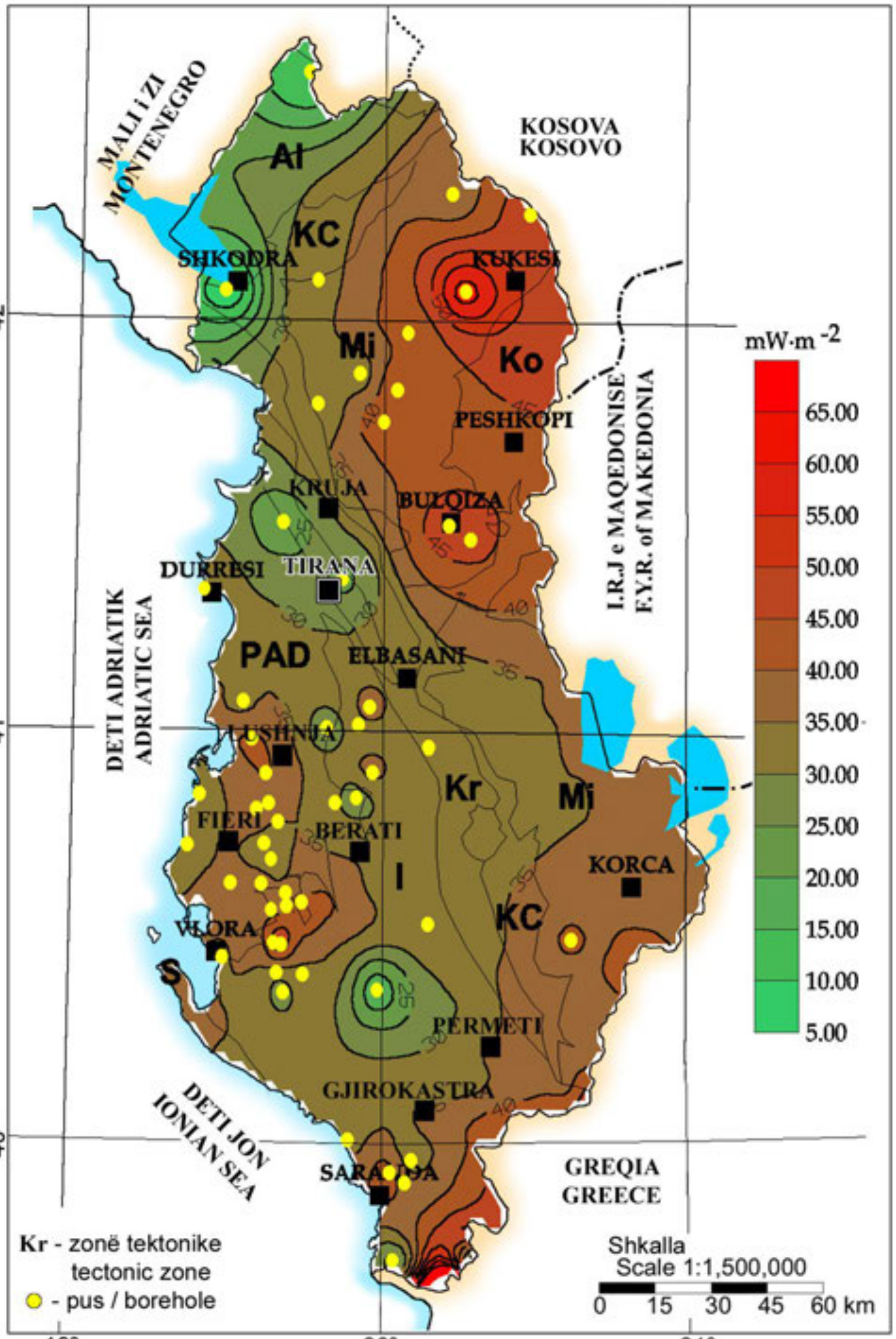
Harta e temperaturës në thellësinë 100m
Temperature Map at the depth 100m

Fig. 1



Harta e temperaturës në thellësinë 3000m
Temperature Map at the depth 3000m

Fig. 2



Harta e dëndësisë së fluksit të nxehtësisë
Heat Flow Density Map

Fleta / Plate 16

Fig. 3

Fig. 4

GEOTHERMAL ENERGY RESOURCES IN ALBANIA

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ABSTRACT

Geothermal energy of low enthalpy sources in Albania are presented in the paper. Geothermal sources in Albanian are located in three geothermal zones:

- **Kruja geothermal zone,** with an identifiable resources $5.9x10^8$-$5.1x10^9$ GJ in carbonate reservoirs.
- **Ardenica geothermal zone** in sandstone reservoirs, and
- **Peshkopia gjeothermal zone,** where the springs are linked with the disjunctive tectonic seismic-active zone.

The geothermal situation of low enthalpy in Albania, offers three domains for the direct use of geothermal energy:

First, geothermal heat pump system for space heating and cooling.

Second, thermal waters of low enthalpy are natural sources or wells in a wide territory of Albania. They represent the basis for a successful use of modern technologies for a *complex and cascade direct use* of energy.:

Third, the use of deep abandoned oil and gas wells as “Vertical Earth Heat Probe”.

KEYWORDS: Geothermal energy, geothermal regime, heat flow density, low enthalpy, thermal water, direct use.

1. INTRODUCTION

Paper represents a summary of the important results of the geothermal studies and projects in Albania, performed in the framework of the National Program for Research and Developing, Water & Energy (1993-1997, 2003-2005, 2007-2009), agreement between the Faculty of Geology and Mining, and the Geophysical Institute, Czech Acad. Sci., Prague, European Commission- International Heat Flow Commission and UNDP-GEF/SGP Tirana Office projects [1, 2, 3, 4, 5, 7, 10, 11, 12].

In Albania there are many thermal water springs and wells of low enthalpy, with a temperature of up to 65.5°C, which indicates that there are possibilities for direct use of the geothermal energy. In Albania the new technologies of direct use of geothermal energy are either partly developed or remain still untouched. Integrated and cascade use of geothermal energy of low enthalpy will be represent an important direction for profitable investment. Exploitation of geothermal energy will have a direct impact in the development of the regions, by increasing their per capita income and at the same time ameliorating the standard of living of the people.

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2. GEOLOGY BEACKGROUND

The Albanides represent the main geological structures that lie on the territory of Albania. They are located between the Dinarides in the north and the Helenides in the south, and together they form the Dinaric Branch of Mediterranean Alpine Belt. Albanides are divided in two big peleogeographical zones: the Inner Albanides and the External Albanides. Korabi, Mirdita (ophiolitic belt), presents the Inner Albanides and Gashi zones. The Alps, the Krasta-Cukali, the Kruja, the Ionian zone, the Sazani zone and the Pre-Adriatic Depression present the External Albanides. Depression as a part of Albanian Sedimentary Basin, continued towards the shelf of the Adriatic Sea. The geological cross-section of Albanian Sedimentary Basin is about 15 km thick and it continues also in the Adriatic Sea Shelf.

Ionian zone is developed as a large pelagic trough in the Upper Triassic. There, the evaporites of the Permian-Triassic are overlapped by a thick carbonatic formation of the Upper Triassic-Eocene. The geological section on this carbonatic formation is covered by Oligocene flysch, a flyschoid formation of the Aquitanian and by schilieres of the Burdigalian, Helvetian and particularly of Serravalian- Tortonian molasses. Burdigalian deposits are overlapped transgressively with an angular unconformity, anticline belts. The Tortonian Age deposists have filled the synclinal belts of Ionic and Kruja tectonic zones.

Miocene and Pliocene molasse of Peri-Adriatic Depression overlies the structures of northern part of the Ionian zone. The structure of Neogene molasses represents the upper tectonic stage of the structure of the Peri-Adriatic Depression.

In the over part of the section of Kruja zone, the carbonatic neritic rocks of the Cretaceous-Paleogene age are overlying the Oligocene flysch of a thickness of 5 km.

The structures of the Albanides are typically Alpine ones. The SSE-NNW directions represent their general strike. The structures are asymmetrical and have a western vengeance. Recumbent, over thrusted and over twisted structures are found, too. Generally, their western flanks are affected by disjunctive tectonic.

3. METHODS AND STUDY AREA

Geothermal studies carried out in Albania are oriented toward the study of the distribution of the geothermal field and the natural thermal water springs and wells. Geothermal studies were extended all over the country territory.

The temperatures have been measured and the geothermal gradient and the heat flow density at different depths have also been calculated [2, 4]. Temperature measurements were carried out both in 145 deep wells, in boreholes and in mines, at different hypsometric levels. The temperature in the wells was recorded at regular intervals. It was measured by means of resistance and thermistor thermometers. The average absolute measurement error was 0.3°C. The measurements were carried out in a steady-state regime of the wells filled with mud or water. The recorded data were processed using the trend analysis of first and second degrees. The chemical composition of the waters was found. The output of the springs and wells and their hydrogeology was evaluated.

4. RESULTS

4.1. Geothermal Regime

The Geothermal Regime of the Albanides is conditioned by tectonics of the region, lithology of geological section, local thermal properties of the rocks and geological location [1, 2, 4].

<u>4.1.1. Temperature</u>

The geothermal field is characterized by a relatively low value of temperature. The temperature at 100 meters depth vary from less than 10 to almost 20°C, with lowest values in the mountain regions. The temperature is 105.8°C at 6000 meters depth, in the central part of the Peri-Adriatic Depression. The isotherm runs parallel the Albanides strike (Fig. 1,2). Going deeper and deeper the zones of highest temperature move from southeast to northwest, towards the centre of the Peri-Adriatic Depression and even further towards the north-western coast. The temperatures in ophiolitic belt are higher than in sedimentary basin, at the same depth.

4.1.2. Geothermal Gradient

In the External Albanides the geothermal gradient is relatively higher. The geothermal gradient displays the highest value of about 21.3 $mK.m^{-1}$ in the Pliocene clay section in the centre of Peri-Adriatic Depression. The largest gradients are detected in the anticline molasses structures of the centre of Pre-Adriatic Depression (Fig. 3). The gradient decreases about 10-29% where the core of anticlines in Ionic zone contains limestone. The lowest values of 7-11 $mK.m^{-1}$ of the gradient are observed in the deep synclinal belts of Ionic and Kruja tectonic zones.

In the ophiolitic belt of the Mirdita tectonic zone, the geothermal gradient values increase up to 36 $mK.m^{-1}$ at north-eastern and south-eastern part of the Albania.

4.1.3. Heat Flow Density:

Regional pattern of heat flow density in Albanian territory is presented in the Heat Flow Map. There are observed two particularities of the scattering of the thermal field in Albanides (Fig. 4):

Firstly, maximal value of the heat flow is equal to 42 mW/m^2 in the center of Peri-Adriatic Depression of External Albanides. The 30 mW^{-2} value isotherm is open towards the Adriatic Sea Shelf. These phenomena have taken place owing to the great thickness of sedimentary crust, mainly carbonatic one in this zone.

Secondly, in the ophiolitic belt at eastern part of Albania, the heat flow density values are up to 60 mW/m^2. The contours of Heat Flow Density give a clear configuration of ophiolitic belt. Radiogene heat generation of the ophiolites is very low. In these conditions, increasing of the heat flow in the ophiolitic belt, is linked with heat flow transmitting from the depth. The granites of the crystalline basement, with the radiogenic heat generation, represent the heat source.

4.2. Geothermal energy resources in Albania

Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters with a temperatures that reach values of up to 65.5°C are sulfate, sulfide, methane, and iodinate-bromide types (Frasheri A. et al. 1996, 2004) (Tab. 1, Fig.5). In many deep oil and gas wells there are thermal water fountain outputs with a temperature that varies from 32 to 65.5°C (table 2, Fig. 5)

Albanian geothermal areas have different geologic and thermo-hydrogeological features. Thermal sources are located in three geothermal zones (fig. 5):

Kruja geothermal zone represents a zone with bigness geothermal resources. Kruja zone has a length of 180 km. Kruja Geothermal Zone is extended from Adriatic Sea at North and continues in South-Easter area of Albania and in Konitza area in Greece. Photo 1 shows Lëngarica - Permet thermal springs at southern Albania. Identified resources in carbonate reservoirs in Albanian side are $5.9x10^8$-$5.1x10^9$ GJ. The most important resources, explored until now, are located in the Northern half of Kruja Geothermal

Area, from Llixha-Elbasan in the South to Ishmi, in the North of Tirana. The values of specific reserves vary between 38.5-39.63 GJ/m^2.

Kruja geothermal area represents an anticline structure chain with carbonatic core of Cretaceous-Eocene age. They are covered with Eocenic- Oligocenic flysch. Anticlinals are linear with as length of 20-30 km. They are asymmetric and their western flanks are separated from disjunctive tectonics. Geothermal aquifer is represented by a karstified neritic carbonatic formation with numerous fissures and microfissures.

In the Ishmi area, Ishmi 1-b well has been drilled in 1994. It is situated in the top part of the limestone structure. It is located 20 km North- West of Tirana, in the plain area, near “Mother Theresa” Tirana airport. It meets limestone at 1300m of depth and goes through a carbonatic coupe of 1016 m thickness.

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Table 1. Thermal water springs in Albania

N° of Springs	Location	Temperature in °C	Salt in mg/l	Artesian Spring yield in l.s-1
1	Llixha Elbasan	60	0.3	0
2	Peshkopi	5-43	9	10
3	Krane-Sarande	34		<10
4	Lëngarica-Permet	6-31		>10
5	Shupal-Tirana	29.5		10
6	Sarandoporo-Leskovik	26.7		>10
7	Tervoll-Gramsh	24		>10
8	Mamurras-Tirane	21	26	>10
9	Steam Postenani springs			

Table 2. The oil and gas wells that have self-discharge of the thermal water

N°	Well Name	Temperature in °C	Salt in $mg.l^{-1}$	Self-discharge in $l.sec^{-1}$
1	Kozani	65.5	4.6	10.4
2	Ishmi	64	19.3	4.4
3	Galigati	45-50	5.7	0.9
4	Bubullima	48-50	35	
5	Ardenica	38		15-18
6	Ardenica	32		
7	Semani	35		5
8	Verbasi	29.3		1-3

Photo 1. Lëngarica-Permeti thermal water springs

Photo 2. Geothermal deep well Kozani - 8

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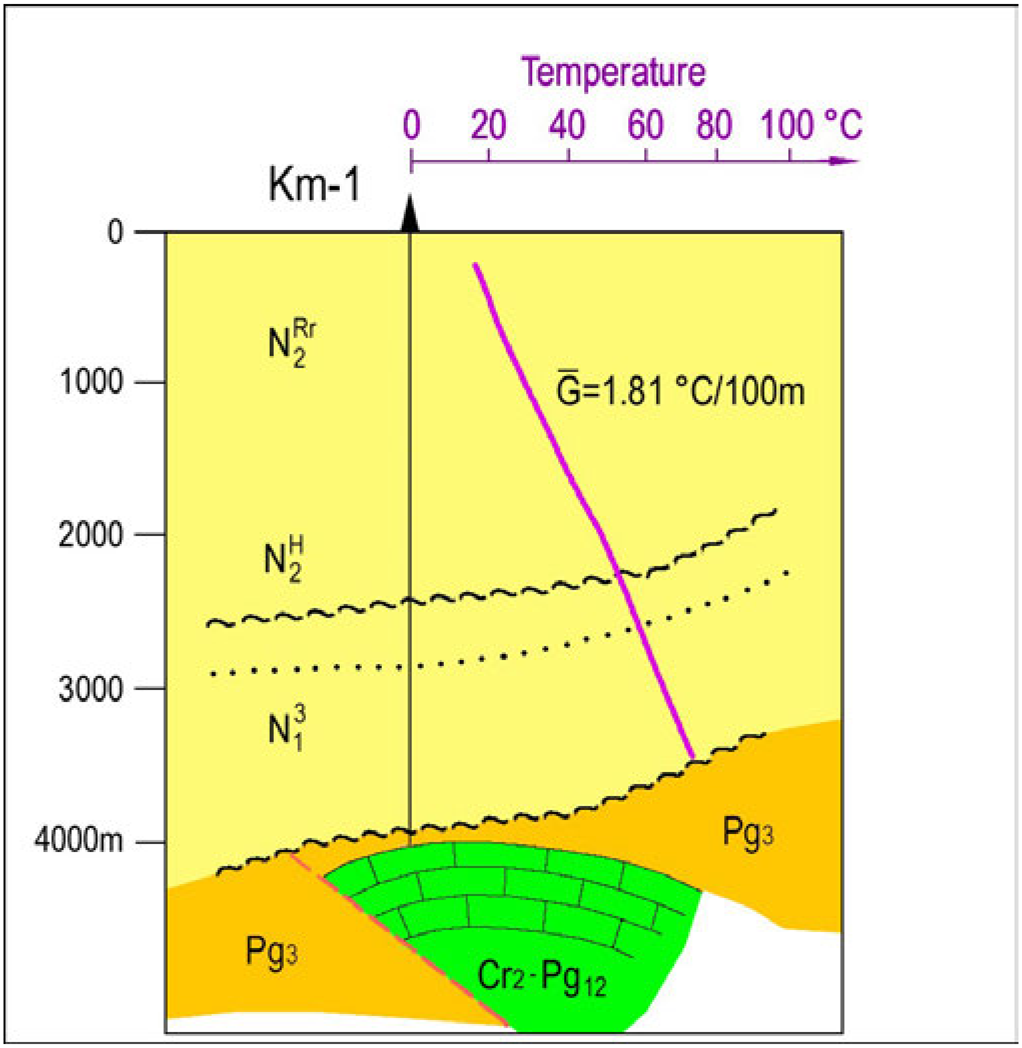
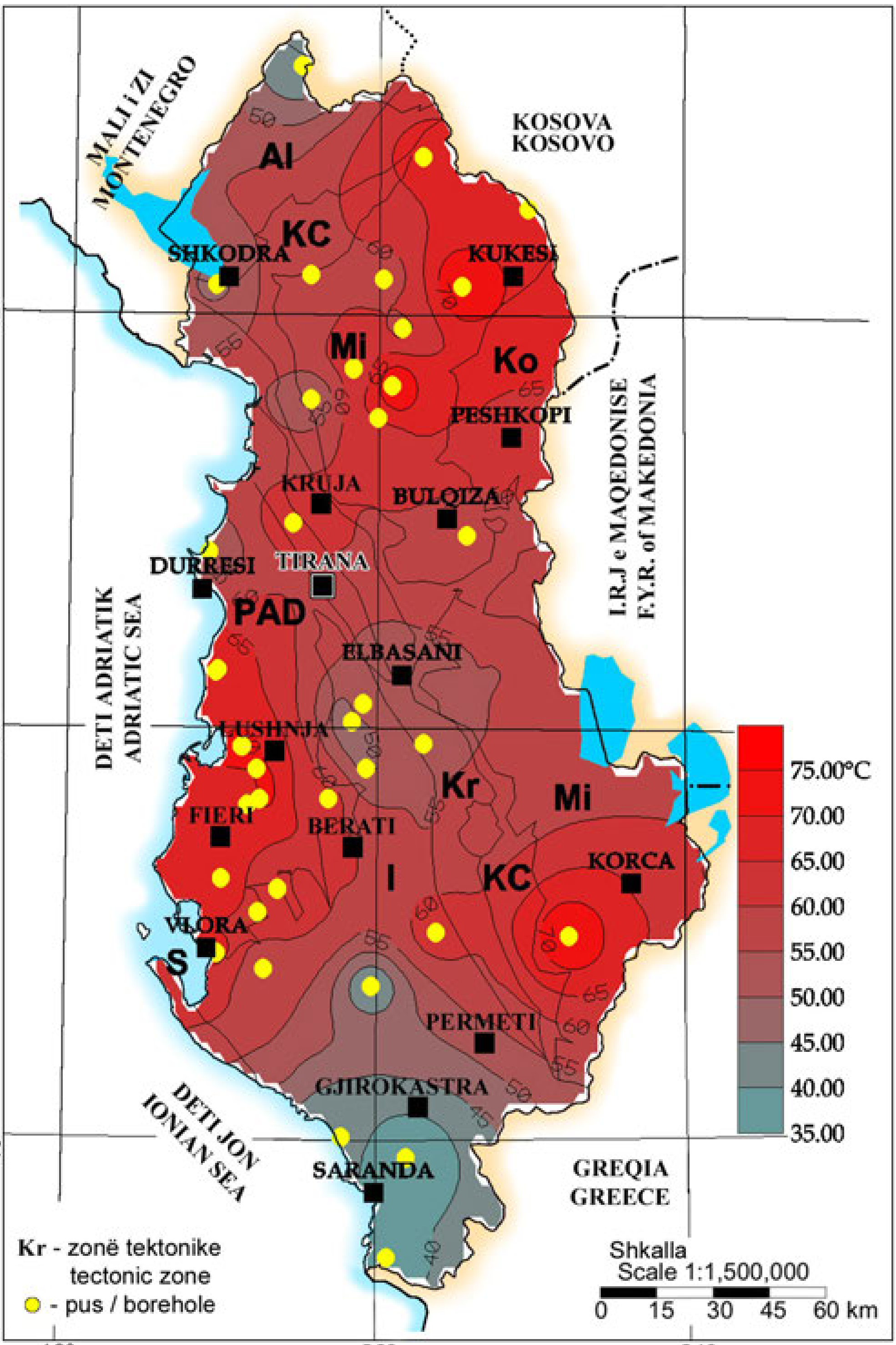
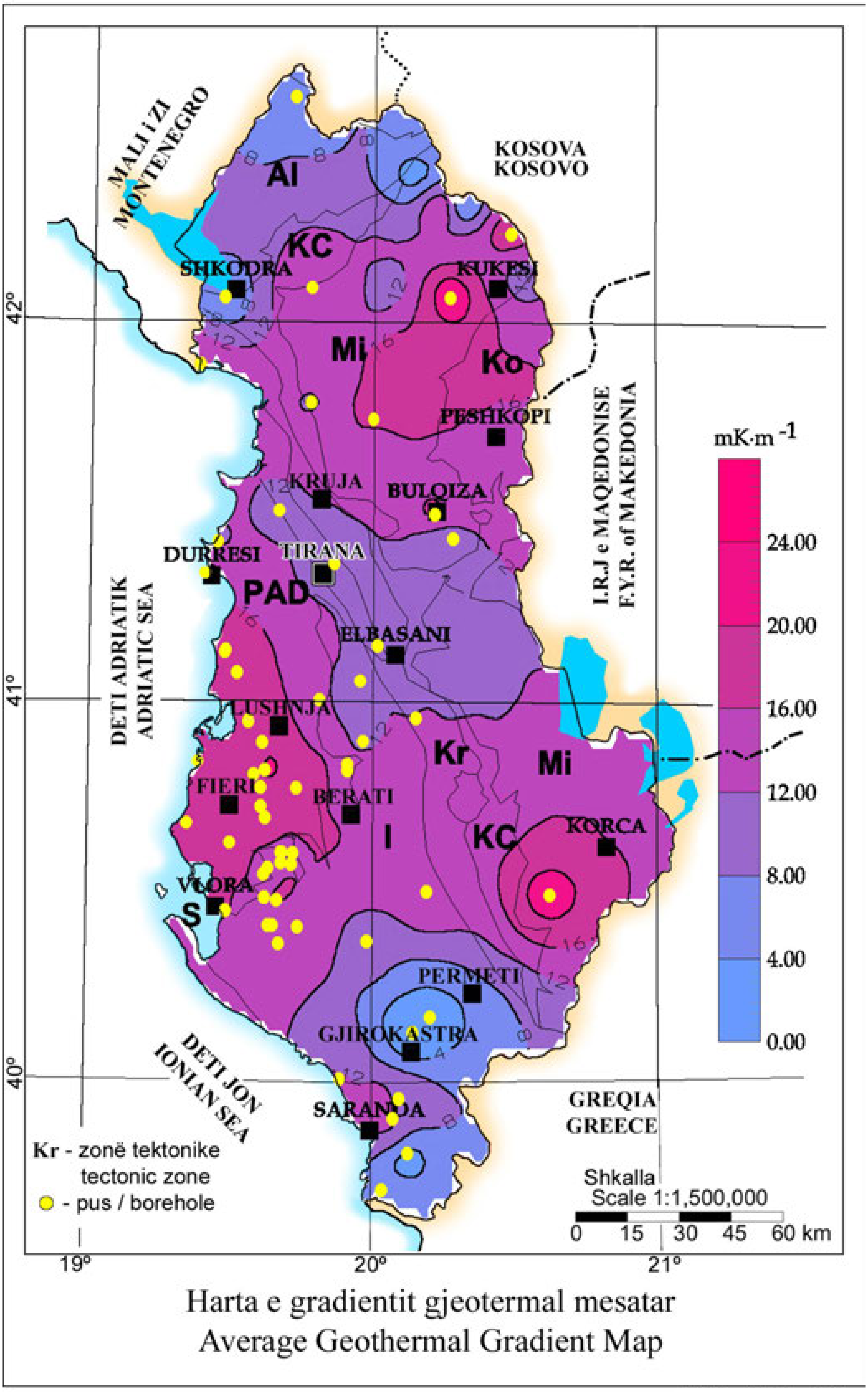


Fig. 1 - Geothermal Section Peri-Adriatic Depression



Harta e temperaturës në thellësinë 3000m
Temperature Map at the depth 3000m

Fig. 2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PERMETI
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DETI ADRIATIK
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I.R.J e MAQEDONISE
F.Y.R. of MAKEDONIA
GREQIA
GREECE
mK·m -1
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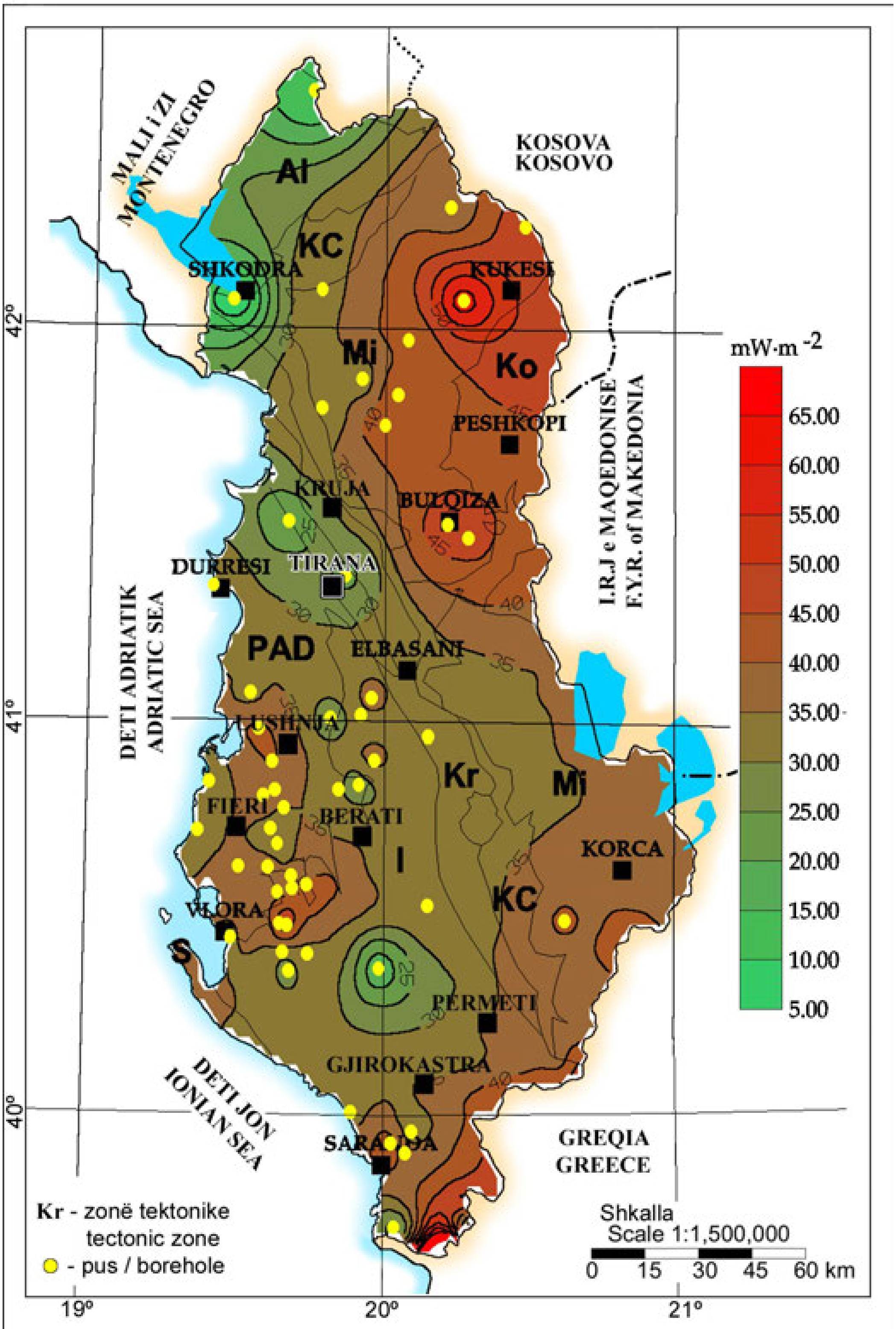
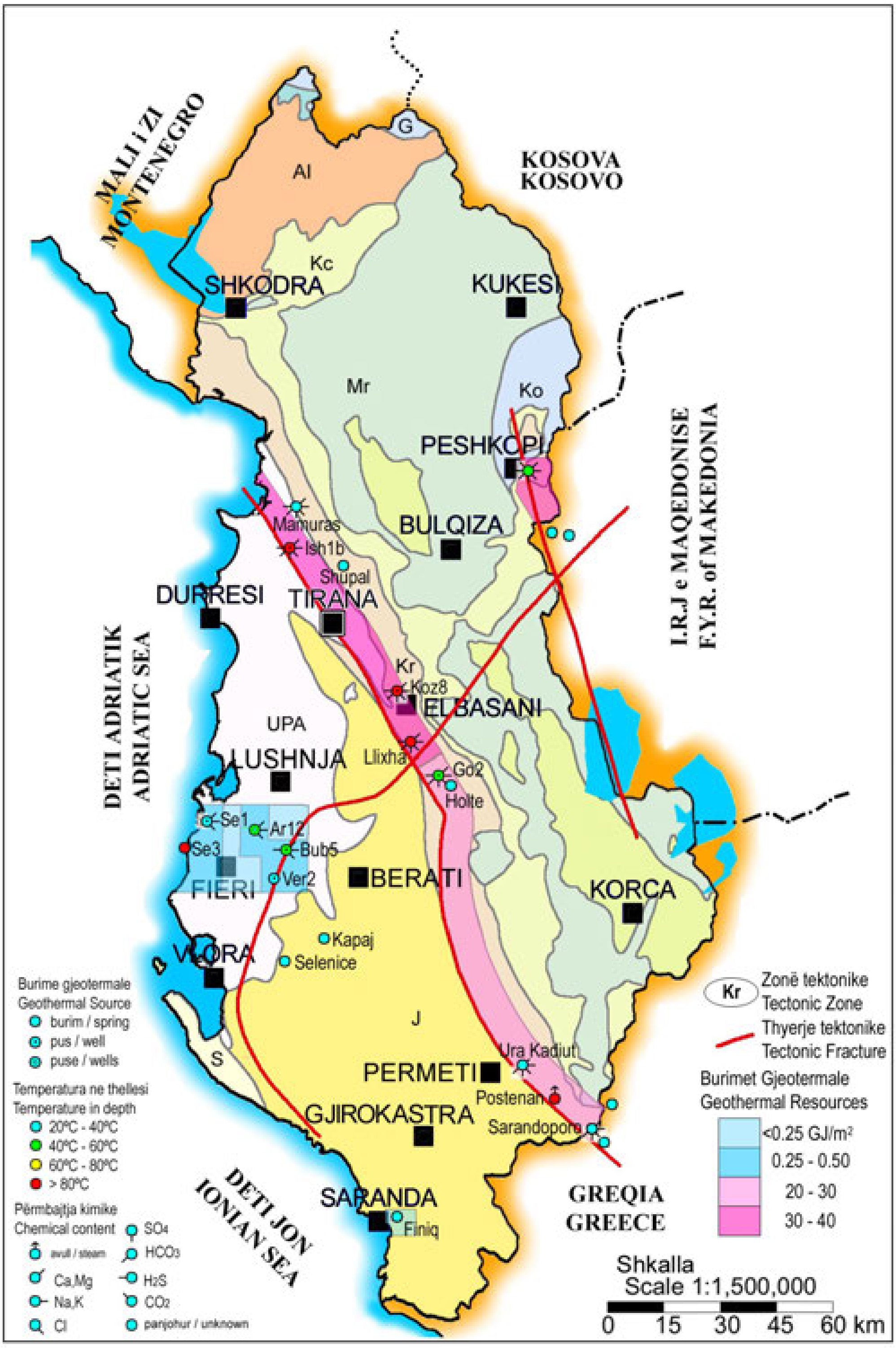
16.00
12.00
8.00
4.00
0.00
Kr - zonë tektonike
tectonic zone
- pus / borehole
Shkalla
Scale 1:1,500,000
0 15 30 45 60 km
19°
20°
21°
40°
41°
42°
Harta e gradientit gjeotermal mesatar
Average Geothermal Gradient Map

Fig. 3



Harta e dëndësisë së fluksit të nxehtësisë
Heat Flow Density Map

Fig. 4



Harta tematike gjeotermale
Geothermal Thematic Map

Fig. 5

The peculiarities of geophysical methods in exploration for chrome deposits

SEG Expanded Abstracts 28, 1310 (2009);
doi:10.1190/1.3255091

ABSTRACT | REFERENCES (7)

Alfred Irfan Frasheri

A half a century history of the application of geophysical methods in exploration of chrome ores deposits in Albania is presented in the paper. There are analyzed the best results and problems, which have solved the Albanian geophysicists, in the framework of integrated multi-disciplinary geological search of for chromite deposits. ©2009 *Society of Exploration Geophysicists*

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Summary:

A half a century history of the application of geophysical methods in exploration of chrome ores deposits in Albania is presented in the paper. There are analyzed the best results and problems, which have solved the Albanian geophysicists, in the framework of integrated multi-disciplinary geological search of for chromite deposits.

Introduction:

The geophysical methods, as a part of integrated geological search for chrome ore deposits, have been applied in Albania to solve two main problems: 1) Direct exploration for ore bodies, and 2) Help in the geological-structural mapping in order to study the factors that control the mineralization.

Albania was ranked at the third place in the world for exploitation of chrome ore, reaching an amount of 960,000 ton/year. There was gained a good experience for the geophysical exploration of chrome deposits and were set up integrated methods for ground and underground surveys. These are achievements of a complex team of geophysicists and geologists.

Field Description

Geologic Setting

The ophiolites of Albanides a rich chromite-bearing belt represent. Chrome ore deposits are concentrated in the ultramaphic massifs, which have tectonic and cumulate sequences. The lower part of tectonic sequence represents the hartzburgite facies with dunitic alternation, composed of fresh rocks in the lower levels up to medium serpentinized rocks in upper levels. Podimorf ore bodies as pseudostratos folded, lens, and column types, have rather big dip angle (Hallaç, H., et al. 1989). The ore's texture is represented as massive, nodular and disseminated one. The content of chrome oxide varies from 20% to (42-44) %. The thickness of the ore bodies, stretching from some tens of meters to some hundreds of meters, (in some cases up to 1550 meters) varies from 0.5 up to 5-10 meters, dipping down to 200 - 400m. The cumulate sequence is situated with angular unconformity over tectonite ones. The dunite with rare alternations of hartzburgite and lherzolite are predominant inside this sequence**.** Chromite in its lower levels becomes more aluminite than in higher levels.

Geophysical exploration

The geophysical complex for direct chrome ore search includes surface mapping by gravity, magnetic and IP methods, and underground surveying. Underground surveying was carried out for the exploration around mine works and bore holes. In order to get the geophysical documentation of the boreholes, are observed the magnetic field, the gravitational field, the IP, the electromagnetic waves, the scattered gamma radiation and the neutron activation (Frashëri, A., 2008,

Lubonja, L. and Frashëri, A.,, 1966, Pumo, E. et al. 1993). Gravity and magnetic mapping have been performed in the complex with geological mapping in the ore field zones. Micro-magnetic survey has been a part of the geological-structural mapping. Petrophysical studies are carried out for the ultrabasic rocks of some massifs and for chrome ores, in some deposits of Albania: density, magnetic susceptibility and remanent magnetization, electrical resistivity and induced polarization (Frashëri, A., 1974, Leka, P., and Vinçani, F. , 2004).

Physical properties of chrome ores and ultrabasic rocks

Density

Iron-chrome ores have a density value from 2550-4380 kg/m^3. The ore's density of Kam Tropoja deposit is mostly determined by its contain of Cr_2O_3, according to the relation, with a correlation coefficient of 0,92 (Frashëri, A., 1974):

$$\sigma = 40.C + 2000 \quad (kg/m^3)$$

where $\boldsymbol{\sigma}$ is the density of chrome ore, in kg/m^3

C is the ore contain of Cr_2O_3 in percentage,

This relation changes from one to another deposit, and from one body to another body. The density of the chrome ore is conditioned also by the degree of the serpentinization of its olivine. The density values of the ultrabasic rocks of tectonic sequence of hartzburgites and dunitic hartzburgites are between 2200 and 3340 kg/m^3. Serpentinized dunites can be distinguished by the predominant density value of 2680 kg/m^3. Massive ores are very well distinguished from surrounding rocks; medium disseminates chromites can be distinguished by serpentinized rocks. Serpentinites and poor chromites are different from the last ones. Dunites and fresh hartzburgites, pyroxenites and also gabbro-pegmatites are differentiated from all kinds of serpentinized ultramaphic rocks.

Magnetism

The magnetism values of the chrome ore and the ultrabasic rocks is unstable and change in a wide range. The magnetism is the most variable property of them. Therefore, chrome ores and ultrabasic rocks can be classified as nonmagnetic, weakly magnetic, and strongly magnetic ones (Frashëri, A., 1974).

Massive texture iron-chrome ore, situated inside fresh ultrabasic rocks, has an induced magnetization (I_i) predominant value of $(500\pm50)\cdot10^{-5}$ SI units. The remanent magnetization of those chromites varies between $(100\text{-}8100)\cdot10^{-5}$ SI units. The remanent

magnetization (I_r) marked reduction down to $100x10^{-5}$ units SI, and the induced magnetization (I_i) reduction down to $300x10^{-5}$ units SI for the ores in the serpentinized rocks. This decreasing can be explained by the magnetization changes of the ferrite. Remanent magnetization vacillates in broader limits than the induced magnetization; especially, for particular samples it reaches up to $97000x10^{-5}$ units SI.

The ultrabasic rocks have a magnetism, which changes in a broad band, conditioned mainly by the presence of the secondary magnetite and less by the magnetized accessory chrome spinel. The fresh dunites and hartzburgites of tectonic sequence are not magnetic. With the increase of the serpentinization process, the magnetization of dunites and hartzburgites gets stronger. This can be explained by the increase of the secondary magnetite and the thermoremanent magnetization. The magnetism of the serpentinites has a particularly characteristic: Its values vary in a wide range, from practically unmagnetic to strong magnetic, with values of $I_r = 70,000 \cdot 10^{-05}$ SI units and $I_i = 3100 \cdot 10^{-05}$ SI units.

Petromagnetic studies have shown the presence of inverse magnetization phenomenon for chrome spinel ores in some deposits. The ores in some deposits are characterised by vectors of remanent magnetization oriented in the average azimuth Φ=356° and with dipping angle θ=-70°, i.e. opposite to the direction of the vector of remanent magnetization for surrounding rocks in the Albanian territory location.

Induced polarization chargeability (IP)

The chrome spinel ores and the ultrabasic rocks are characterised by IP chargeability values from 2-600 mV/V. They may be from unpolarizable to strongly polarisable. The rich chrome spinel ores has an IP chargeability which varies from 7 to 300 mV/V. The ores of average and dense dissemination have the highest IP values. The ore cannot be polarized does not contain secondary magnetite. The ore has a polarizability up to 40 mV/V when it has small quantities of secondary magnetite in the form of detached spots. The polarizability is increased many times, not only when the quality of magnetite is increased but also when it is placed very thin chains and veinlets, with a thickness about 0,00064-0,0032 mm.

The IP coefficient of cumulate sequence ultramaphic rocks varies in a wide range than in the chromites. If the maximal value of this IP coefficient reaches in 300 mV/V for the chromites, in the investigated rocks this one reaches up to 510 mV/V. The secondary magnetite, in the cumulative sequence dunite, is present in the form of veinlets. The fresh and the serpentinized rocks that do not contain secondary magnetite practically are not polarized (η<20 mV/V). There are also defined the dependence of polarizability on the resistivity of the ore and the ultrabasic rock. With the increase of the resisivity, polarizability is increased and reaches the maximal values in the samples with a resistivity of 100.000 Ohmm. With the further increase of resistivity, the polarizability begins to decrease.

The amplitude of the induced polarization also depends on the density of the polarizing current..

Based on petrophysical properties of the ultramaphic rocks and chrome ores it was concluded:

1. The density is a more stable and typical physical property, which can be used for distinguishing chromites from the surrounding rocks. Therefore the gravity method is the basic geophysical method for the search for chrome deposits.
2. There are strongly polarisable or magnetic ores whose density values have very small differences or no differences from the surrounding rocks. The bodies created by these ores, especially when they are situated between fresh rocks, are objects for the magnetic and geoelectrical surveying.
3. There are chrome ores, which have the same or similar features with the surrounding rocks. These ore bodies cannot create local anomalies of physical fields and cannot be studied by geophysical methods. For example the disseminated structure ores, which have an average density value of 3300 kg/m^3 and 32% of Cr_2O_3 contain, cannot be discriminated from the fresh dunite of the same density value.
4. The physical properties of the ultramaphic rocks vary within broad limits and only in some cases a group of rocks can be differentiated by its physical properties from the surrounding rocks. The cumulate and the tectonic sequences are discriminated. These groups of rocks can create geophysical anomalies comparable with the ore body anomalies.
5. The study of the orientation of the remanent magnetization vector of the ores and the surrounding rocks can be used as a supplementary information source about their formation conditions and consecutive changes in time.

Application of geophysical methods in search for chrome deposits in Albania- case studies

Exploration for chrome ore bodies

The gephysival explorations carried out in most important Bulqiza ultrabasic massif can illustrate the effectiveness of the geophysical search for chrome ores. Geological and geophysical mappings, at scale 1:2000 have been conducted in total over 65 km^2 or in 15% of surface of the Bulqiza massif (Langora Ll. et al.. 1989). There are observed 215 geophysical anomalies have been fixed. Among them, 191 anomalies have been observed by only of one geophysical method, and 24 ones present complex anomalies: gravity, magnetic or IP. Fifty one anomalies were fixed over the known chromite bodies/occurrences and have contributed for their development in the strike direction. Thirteen anomalies have been discovered buried chromite bodies without surface outcrops. Thirty-five anomalies have been evaluated as very important for exploration and development works. Hundred sixteen have been non-mineralised anomalies; which are caused by particular rocks, tectonic faults, and topographic effects or by the change of the thickness of the deluvion.

Geophysical anomalies caused by ore bodies have been observed in several areas. Over the ore bodies, weak

gravity anomalies are observed, with amplitude, about 0,1-0,2 mGal (fig. 1). These anomalies are more evident after the field transformation in vertical gradients of the gravity potential W_{zz} and W_{zzz} (fig. 2). Intensive and wide magnetic (positive or negative), and IP anomalies have been observed over a chromite ore bodies (Fig.3, 4).

Underground geophysical surveys

Underground geophysical surveys in boreholes and galleries have been performed to solve the following problems:
1)The search around mine works.
2)The outputs of the radio wave floodlighting and radio wave profiling give good results when the chrome ore is magnetic.
3) IP methods can be used for the search of polarised ore bodies around boreholes by using the pole-dipole array N5M5A,B→∞ and N10M100A,B→∞, which can investigate a zone of a radius 7m and 60m, respectively.

Well logging

The main method used for documentation of the borehole is the density and selective gamma-gamma logging.

Geophysical applications for geological mapping

Geophysical surveys for geological structural mapping purposes have contributed, aimed at successfully solving some regional and local problems. The structure of ultramaphic rocks massifs and their relationship with the surrounding media have been studied (fig. 5).

Micro magnetic survey has given good results in determining the primary textural elements in zones covered by 2-3 m thick soft sediments and in zones where these elements cannot be seen.

Conclusions

1) Geophysical anomalies are fixed on ore bodies and on rock inclusions. That means, not every anomaly may indicate about the presence of an ore body. On chrome ores there are not always geophysical anomalies. That means that the lack of anomalies does not necessarily indicate about the absence of ore bodies. The wide variation of the ore's physical properties and those of the surrounding rocks can explain these alternatives. A geophysical anomaly can indicate only about the possibility of the existence of a chrome ore body.

2) According to mathematical modllings, by gravity surveys is possible to discover chromite bodies in different depth, from tens to hundred meters, if will exist necessary mass of the ore body. For example, the ore body with radius 14,5 m and mass 50.000 tons, is possible to explorer up to 23,5 m depth of location, because the Bouguer anomaly will has an amplitude about 0,2 mGal. The mass about 3.500.000 tons can be explored at 200 m depth of location, by survey such anomaly, 0,2 mGal. These limitations create the need for the implementation of some measures to increase the effectiveness of geophysical search:

3) Direct search for chrome ore bodies should be carried out simultaneously with the geophysical-structural mappings and petrophysical studies in order to know the factors controlling the mineralisation and geophysical anomalies.

4) Surface and underground geophysical surveys (gravity, magnetic, geoelectrical ones) should be carried out in complexity. In the interpretation of the results should be considered all other existing geological information. This will make possible the determination of the nature of an anomaly, so that the ones caused by ore bodies can be selected. Better combination of surface with underground surveys leads to the increase of the search depth of the geophysical methods.

5) Geophysical works can achieve better results when perspective zones are the exploration objects. The work should start from well-known ore bodies and not from small sectors.

6) Geophysical studies should be carried out in the framework of complex geological research. Only in this way can better be studied the geology of the ultramaphic massifs, the premises for the search of ore deposits and ore bodies underneath the surface of the Earth.

7) Since the number of shallow or near- surface ore deposits is decreasing, the implementation of geological methods, at present, is a necessity in order to increase the search depth for chrome deposits.

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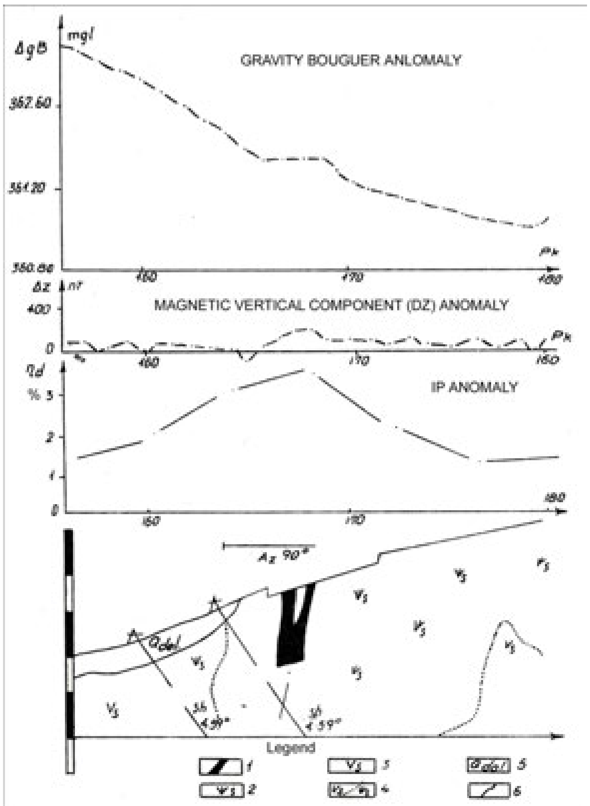

Fig. 1. Geological-Geophysical section in Qafe Gjela deposit (Bulqiza massif) (Frashëri A, 2008, after Prenga Ll. et al. 1983).

1 - Ore body, 2 - Serpentinized dunite, 3 - Serpentinized hartzburgite, 4 - Smooth-rock border, 5 - Deluvion, 6 - Tectonic fault.

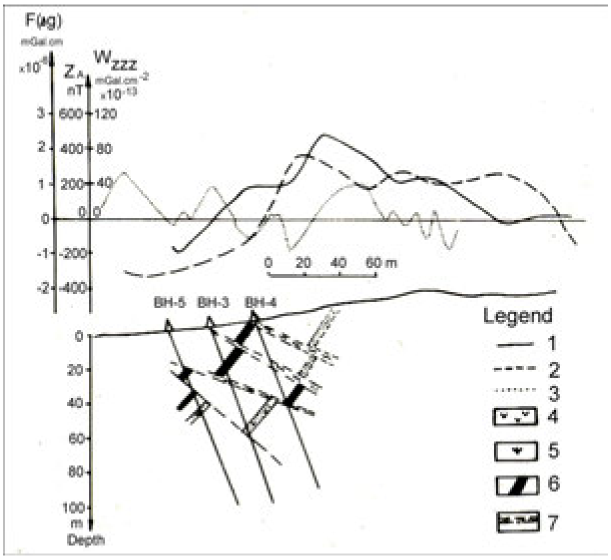

Fig. 2. Geological-geophysical section III-III for projecting of the boreholes to check the residual gravity anomaly, Kam deposit. (Frashëri A, 2008, after Lubonja L. et al. 1973).

1- Wzzz profile; 2- F(Δg) profile; 3- ΔZ profile; 4- Dunites; 5- Hartzburgites; 6- chromite ore body discovered by projected boreholes; 7- Disjunctive tectonics.

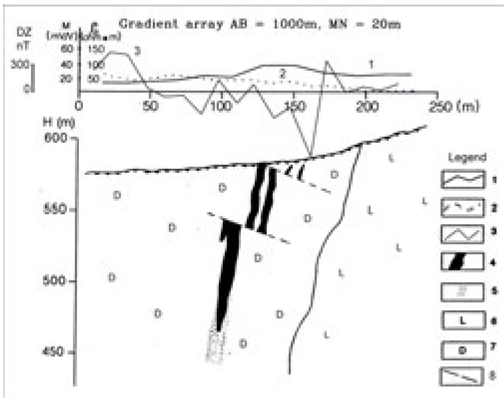

Fig. 3. Magnetic and IP anomalies over the Vlahna deposit (Tropoja massif) (Lubonja L. et al. 1966).

1- IP anomaly; 2- Apparent resistivity profile; 3- Magnetic anomaly (ΔZ); 4 – Masive chromite ore body; 5- Disseminates chromite; 5 – Hartzburgites:

6 – Dunites; 7 - Disjunctive tectonics.

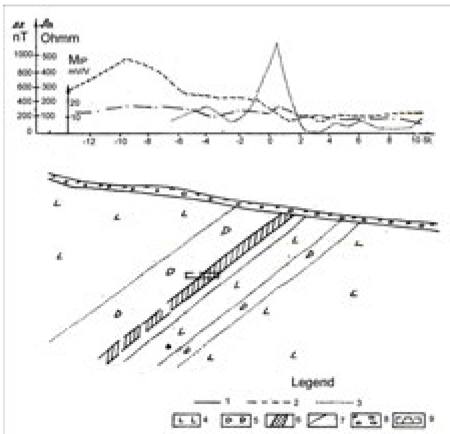

Fig. 4. Geological-geophysical section with a positive magnetic anomaly over a chromite ore body, Leshnice area, Kukesi ultrabasic massif (Frashëri A. 2008.

1- IP anomaly; 2 - Apparent resistivity profile;

3 - Vertical component (DZ) of magnetic field profile;

4 – Hartzburgites; 5 – Dunites; 6 - Ore body; 7 – Gradual geological boundary; 8 – Deluvion; 9 - Gallery.

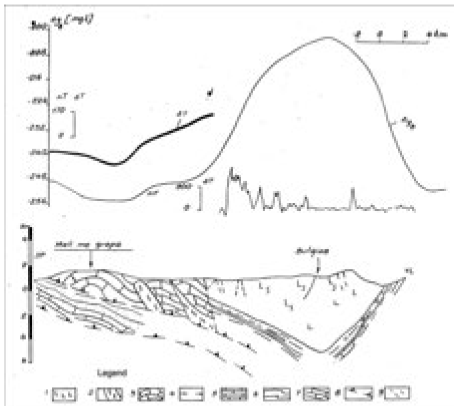

Fig. 4. Geological-geophysical line in Klos-Bulqizë-Shpuzë (Frashëri A. et al. 1990).

1 - Hartzburgites, 2 - Serpentinites, 3 - Triassic limestone, 4 - Volcano-sedimentary series, 5 - Jurassic limestones, 6 - Cr^2 - Pg^3 flysch, 7 - Pg^2 limestone,

8. Cover tectonics, 9 - Disjunctive tectonics.

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ALBANIAN GEOPHYSICS AND FACING THE CHALLENGES DURING THE TRANSITION PERIOD TOWARD FREE MARKET ECONOMY

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Abstract

In the speech are presented the development of the geophysical exploration in Albania, contribute of the geophysics and facing the challenges during the transition period toward free market economy.

Albania is a rich country in mineral resources, chrome, copper, iron-nickel, coal, oil and gas etc. The exploration for these mineral deposits is carried out successfully by using a wide and complex range of geological, geophysical and geochemical methods. There are tens of oil and gas reservoirs, tens of copper, chromite, etc. deposits that have been discovered through geophysics contribution. Gravity, magnetic, geothermal and seismic zoning maps of different scales up to 1:200.000 and 1:500.000 are important part of regional studies on the recognition of geological setting of Albanides. Geophysical studies and research are conducted in Albania for more than 70 years. The first geophysical researches have been performed during thirty years, with gravity, and magnetic survey, vertical electrical soundings, by Italian companies in the years 30-40. Geophysical research in large polygons for oil and gas reservoirs, and copper, chromite deposits explorations began systematically to 50 years period. Gradually, step by step, we have applied different geophysical methods. The successful Albanian geophysics in search for metallic deposits and oil and gas reservoirs have been published in many papers in national and international scientific press, and presented in the national and international meetings.

On shore and of shore oil and gas exploration have been performed using seismic reflection surveys, gravity mapping, and small volume of the vertical electrical soundings. Mining geophysics for copper, chromite, bauxites deposits exploration is developed through application of the gravity and magnetic mapping of different scales, induced polarization profiling and real-section surveys, electromagnetic profiling, resistivity profiling and vertical electrical soundings, self potential mapping. Radiometric and nuclear geophysics have been used for phosphorite research. Oil and gas, copper, chromite, phosphorite, coal wells have been studies using complex of the electrical, sonic, radioactive and nuclear well logging,

Important direction of Geophysics presents seismological studies in Albania. These studies have been developed to three areas: seismotectonics, seismology and seismologic engineering.

Last two decades represent the period of extension of the field of application of shallow engineering and environmental geophysical methods to solve the geotechnical tasks, hydrogeological research,

the micro-zoning of main Albanian cities, the study and evaluation of geothermal energy, and environmental studies for impact evaluation and water pollution, etc.

Geophysical Branch in the Faculty of Geology and Mining, Polytechnic University of Tirana, during a half of century period from 1961 up to present have graduated 304 geophysicist engineers, and 48 doctors of sciences.

Albanian Geophysicists have established since 1989 Geophysical Society of Albania (GSA), which is part of the Albanian Association of Geoscientists and Engineers (AAGE). GSA is a member of the European Association of Geoscientists and Engineers (EAGE) and the Balkan Geophysical Society (BGS).

Key words: Albanian Geophysics, Mining Geophysics, Oil and Gas Geophysics, Engineer and Environmental Geophysics.

Introduction

Albania is rich with natural resources: oil, gas and solid minerals (Fig. 1). Integrated geological-geophysical-geochemical prospecting have discovered and developed tens of solid mineral deposits, and oil and gas reservoirs in Albania.

In order to demonstrate the economic capacity of the Albanian Mining and Petroleum Industries, it is sufficient to indicate that only during 1984 there were extracted 1,007,000 tons of copper minerals and processed 12,600 tons of blister copper, as well as 960,000 tons chromites. The average income from the copper and chromium extracting industries was 120 million USD. About 20 million tons of copper minerals and 21 million tons of chromites have been extracted by the Albanian Mining Industry. Oil production reached a peak of 2.250.000 tons in 1973. Up until 1990s, there were extracted 49, 5 million tons of oil, about 12 million cubic meters of natural, and 47 million tons of coils. Unfortunately, during the transition period among 1990 to 2010, the volume of extraction by the mining and oil industry has steadily decreased. According to the official statistics, INSTAT, the mining production has decreased as following: 88.6 in 1994, 86.5 in 1995, 75.8 in 1996, 47.1 in 1997, 74.5 in 1998, 35.5 in 1999, 31.0 in 2000, and 27.0 in 2001.

Geological prospecting have evaluated the mineral resources, capable of extraction as 31 million tons of oil, 53 million tons of cooper minerals, 40 million tons of chromites, 220 million tons of Ferro nickel, 100 million tons of nickel, 700 million tons of coil. More than twice of the extracted copper and chromites ores are estimated by geological exploration and developing statement of the resources for the future.

The Bitumen from the Selenica mines in southern Albania has been extracted since the ancient times. Illyrian tribe of pirusts was well known for copper processing. An activist of the Albanian Renaissance, the philosopher Sami Frashëri, in his book "Albania, What It Was, What It Is, and What Will It Be (1899), wrote "...it is necessary to explore all metals all over Albania ... In the capital of Albania, in addition to secondary schools must be a university, and an academy….. to develop in Albania the literature, history,…. and geology, etc.". Nearly half a century later, a politician Mehdi Frashëri in his book "The Albanian Problem" (1944) wrote: "… At near future, Albanian oil in Kuçovo as well as in Patos will form a source of national wealth and a key target for state revenues " and "… in Albania there have been explored some ores, which can also reasonably be used for developing the economy and industry of the country….".

In the 1920s and 1930s, oil was discovered in Kuçova, and it was processed, also copper was extracted in Rubik, and a little later started the extraction of chromium. The programs elaborated by our philosophers and statesmen were fully

implemented after the World War II. The new state took particular attention to further developing the exploration, extraction and processing of the natural

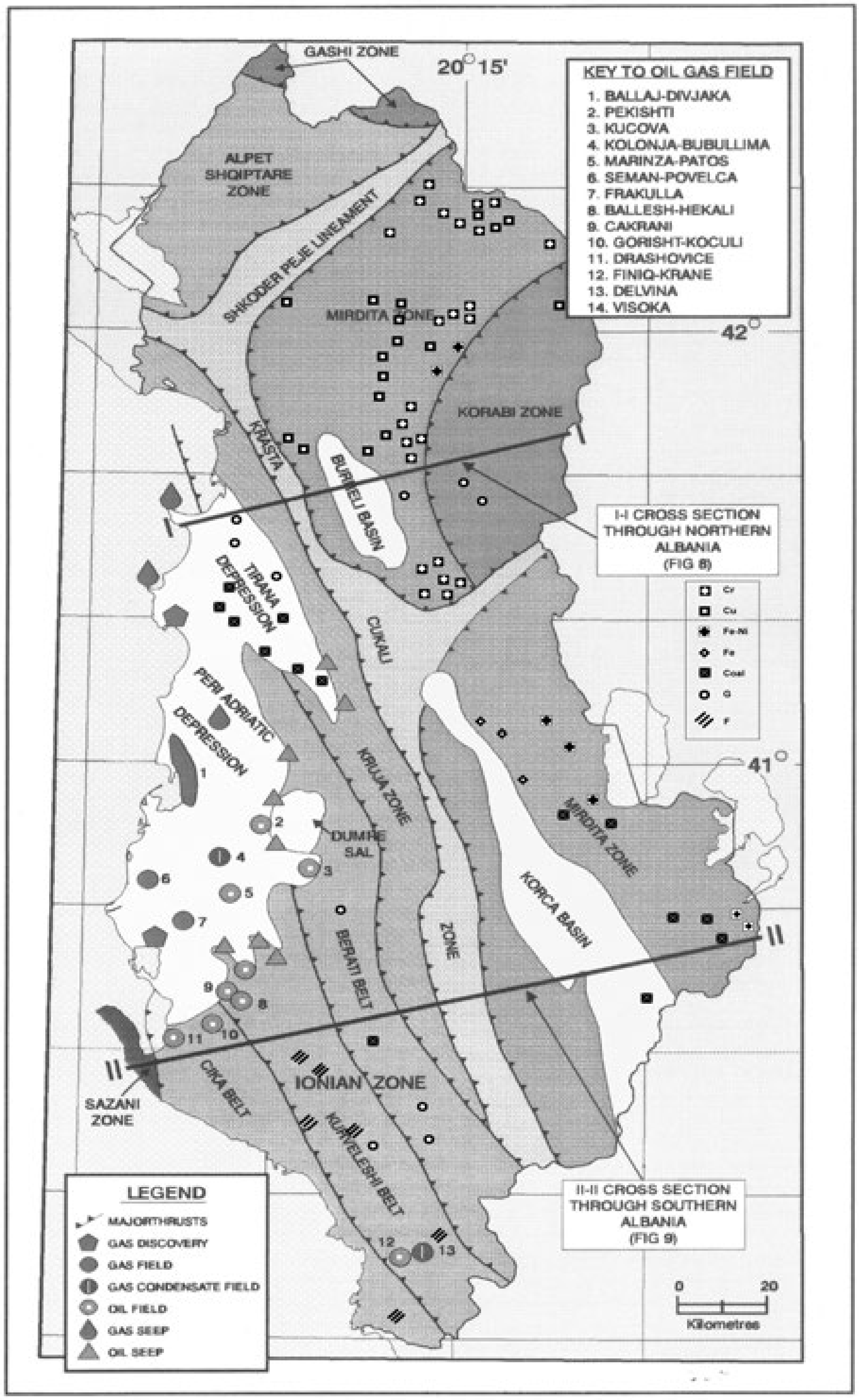

Fig. 1. Important oil and gas reservoirs and solid minerals deposits in Albania.

resources, and it put those industries at the cornerstone of the socio-economic development of Albania. The development of those industries went hand in hand with the formation of a new cadre of young specialists, who were able and willing to explore and to extract the mineral wealth of the homeland, and to selflessly contribute to the development of the state and economy.

Geophysical studies and research are conducted in Albania for more than 70 years. First gravimetric and magnetic surveys and electrical soundings have been performed during thirty years by Italian company. Geophysical research in large polygons has started systematically from 1950 year for oil and gas, gradually to apply different methods: Gravity survey, Vertical Electrical Soundings, and Well logging (1950), Seismic surveys (1952). From 1953 has started application of the Geoelectrical surveys for cooper exploration, magnetic surveys (1957) and gravity surveys (1958) for chromite exploration. Radiometric surveys (1959), and geothermal studies (1989). Offshore seismic and geoelectrical surveys in Albanian Adriatic Sea Shelf for oil and gas exploration have started from 1982. Geophysical research in fifty's years was performed by Soviet and German geophysicists. From 1952 he returned from overseas studies two first Albanian engineers. At that time was formed also the first geophysicist's technicians. After 1961, all geophysical surveys have been performed by Albanian geophysicists. For two years in the seventy's years, the Albanian geophysicists have worked together with the Chinese geophysicists. Today, after 60 years, there are 304 geophysicists, as well as dozens of physicists, electrical engineers, etc. that have working on geophysical surveys. Among them are 48 doctors of sciences, 7 professors, and 22 leading researchers and masters.

Albanian Geophysicists have established since 1989 Geophysical Society of Albania (GSA), which is part of the Albanian Association of Geoscientists and Engineers (AAGE). GSA is a member of the European Association of Geoscientists and Engineers (EAGE) and the Balkan Geophysical Society (BGS).

Geophysical studies in Albania, year by year have been developed as complex methods, such as technological level of the surveys and interpretation, and are raised up coordination with other geological and geochemical methods. The realization of the development of Geophysics at the beginning of the period 1972-1986 is sensitive behavior of equipment and modern technologies for seismic, gravity, geoelectric, magnetic surveys, radiometric studies and well logging.

Geophysical Exploration and studies have been performed in the framework of the three Geophysical Enterprises [Biçoku T., 2004, Frashëri A. et al. 2010].

1. Oil and Gas Seismic and Gravity Enterprise in Fieri City: 70 geophysicists enginees, four seismic teams, gravimetric one, a geoelectrical team, as well as marine expedition with seismic, geological and geoelectrical teams. Enterprise has realized about 2500 km/year of seismic profiling by multiple coverage.

2. Oil and Gas Well Logging Enterprise in Patosi City: 30 geophysicist's engineers, the electric, radioactive, sonic groups, gas logging, and perforator's groups, laboratory of physical properties of the rocks and interpretation group. Well logging groups carry integrated geophysical study of exploration deep wells for oil and gas with an annual volume of 80,000 linear meters of wells with a depth up to 6700 m, and tens of thousands linear meters of production wells.

3. Geophysical Enterprise of Tirana for mining geophysics: 106 geophysicist's engineers. Geoelectrical Teams have realized about 35-40 km^2/year mapping at the scale of 1:10 000, 1:5.000 and 1:2.000. Averagely the same area has covered also by the gravity and magnetic survey. In 2008, the restructuring of the Albanian

Geological Service, the company was reformed: several specialists went to the Institute of Earth Sciences was established, some remained in the unit geophysical Albanian Geological Service.

Application fields and geophysical methods applied in Albania

Tab. 1

GEOPHYSICS	Methods	Application fields			
		Oil & gas	Mining	Engineering & Environmental	Regional
Applied	Seismic reflection	++		++	+
	Electrical	+	++	++	+
	Gravity	+	+	+	++
	Magnetic		+	+	++
	Well logging	++	+	+	+
	Radiometric		+	+	+
Seismology	Earthquakes	1. Seismological Surveys Network 2. Seismological zoning of Albania			
	Engineering	1. Seismic Micro zoning and seismic risk evaluation 2.Seismic monitoring of the hydropower plant dams			
Geothermic	1. Geothermal studies 2. Geothermal energy platform and use scenarios.				

++ Principal method

In Geological & Geodesic Enterprise of the Ministry of Construction and in the Hidrogeological Enterprise of Tirana have two specialized geophysical expeditions for engineering geophysics (1983) and water research (1980).

Important direction of Geophysics in Albania presents the seismological studies, which have been conducted by the Institute of Seismology, Academy of Sciences. These studies pertain to three areas: seismotectonic, seismology and earthquake engineering. The first seismic station was established in 1968, at the Chair of Geophysics, Faculty of Geology and Mining. Seismological Institute was established in 1973 at the Academy of Sciences. Has been set-up the seismological network with 13 stations in Albania. In 2008 the institute, was involved in the Institute of Earth Sciences in the Polytechnic University of Tirana

Teaching of Applied Geophysics case began in the Geological of Department of the Polytechnic Institute of Tirana (1955). The formation of geophysical engineers and their post graduate training since 1961 have been performed in the Geophysical Branch, Chair of Geophysics Faculty of Geology and Mining, Polytechnic University of Tirana. The period of study was five years for engineers [Frashëri A. et al, 2008].

Geophysicists of all generations have given outstanding contribution to the discovery of ten oil and gas reservoirs, eleven copper deposits, and many other solid minerals. They have performed geophysical regional studies of the Albanides. There are 637of papers published in national scientific journals, 33 of papers published in international scientific journals, and hundred papers that have been presented to major success in international scientific meetings [Biçoku T. 2004, Frashëri A. et al. 2010, Papa A. 2001, Rama M. 1995].

Unfortunately, during a very difficult post communist transition among 1990 to 2010, geological research and other scientific activities, including the geophysics went downhill. Geophysical companies were reformed and closed, the volume of work has fallen to the minimum possible, leading to zero discovery of oil and gas, as well as solid useful minerals. The geophysics branch in the Polytechnic University of Tirana was recently closed. There is only option for t Scientific Master Diploma on geophysics. Many of the best geophysicists have migrated and actually work in their specialty in France, U.S.A., and Canada etc.

Despite all these processes for geophysics and geological researches, the Albanian geophysicists currently in Albania are trying to save the geophysics in the conditions of the Albanian market economy. We have started to widen the field of the application of geophysics in other areas. We are convinced that the geophysical surveys, with modern equipment and software, are as important to geological exploration and studies as the X-ray equipment and echo-sounds are to the doctors. Therefore, geology without geophysics risks a return to the nineteenth-century level.

Last two decades represent the period of extension of application fields of geophysical methods for solving geotechnical tasks, hydrogeological research , micro zoning of the main cities of Albania, geothermal studies and evaluation of geothermal energy, geoenvironment studies and its impacts assessments, archaeological geophysics, etc. An important contribution has been given by joint projects with other institutions and academics as well as professionals from leading countries in the field. Unfortunately, Geotechnical and Environmental Geophysics surveys, there are not to the extent appropriate of modern techniques and technologies, particularly for the evaluation of natural geologic hazards.

However, in order to assess the new scientific research, inter alia, it is necessary to ask and analyze what was done, how it was done, and to determine future goals and objectives. In order to present a modest contribution in this direction, we have made a review of the Albanian Geophysics in the years 1950 to 2010.

1 The role of geophysical methods in the framework of integrated oil & gas exploration

Integrated geophysical exploration for oil and gas had the reflection seismic survey as the main method. Besides its, prospective regions for oil and gas have mapped by gravity surveys. Have been used also some vertical electric soundings. Successful experiments, but in small volume, were also made for direct search of oil and gas reservoirs by complex of methods: natural electric field, radiometric and magnetic surveys. All deep oil and gas wells have studies by integrated well logging methods.

History of the development of seismic work can share in the four main stages:

1. 1952-1970: Oscilographic recording, and manual processing and interpretation of the seismic data. The works were carried out in lowland terrains.

2. 1970 to 1978: Analog magnetic recording, multiple coverage profiling, and surveys were extended also in rugged terrain, with complicated geology.

3. 1980 to 1990: Digital recording and processing of the seismic data, the widely used multiple coverage, and improvement data processing.

4. After 1990 there were gradually declining to zero geophysical exploration works for oil and gas by Albanian geophysicists. Actually, performing of the seismic exploration there is realized by foreign companies.

Gravity survey on the scale 1:100.000, and 1: 50,000 and 1:25.000 have covered the whole perspective territory for oil and gas bearing.

In 1978 has restarted application of the vertical electric soundings with depth of investigation about 2.5 km. The object for the electric soundings have been identification of the limestone structure top, and evaluation of the sandstone content in the Neogene molasses in onshore, and in the Albanian Adriatic shelf, etc.

In the years 1978-1982 was successfully experimented direct exploration of the oil and gas reservoirs by integrates methods: natural electric field, magnetic and radiometric surveys.

Albanian Well Logging Service has celebrated 80th anniversary. The systematic geophysical study of all oil and gas deep wells was begun in 1950, with electric logging, well deflection and factice diameter measurements. The temperatures were recorded in well with electric thermometers. Were performed first experimentation of the gamma logging, and gas logging.

The main feature of the later period, the launch of sixty years, was the step to the full quantitative and qualitative interpretation of logging data, performance of the logging in the well, and determination of the physical properties of the terigjene productive horizons.

Currently, unfortunately even this direction of the Geophysics is abolished, because there are stopped the drilling of the exploration and development deep wells by Albanian Oil and Gas Industry. There remained only a small nucleus in the oil industry, to study any of Albpetrol well.

2 The role of geophysical methods in the framework of integrated exploration of solid minerals

Geophysical methods, used in the framework of integrated geological-geophysical-geochemical exploration, have an important role in search for solid minerals. The role of geophysical methods has depended on many factors such as the kind of mineral to be prospected, the stage of the search, and the kind of problems to be solved.

Application of geophysical methods has been concentrated in two major directions:

1. ***Direct search*** *for many kinds of solid mineral deposits such as copper sulphide, polymetalic, and chrome ores.*

The methodology of the geophysical exploration for copper ores deposits (from the 1930's until today) and chrome resources (from 1958 until today) in Albania was developed in conformity with the geological tasks to be solved and the scientific-technical levels of the geophysical methods.

Geophysical copper deposits search and development has high efficiency. The geophysical methods application has been depended by **ore body depth** of location, and kind of the mineralization type. Geoelectrical surveys have been main prospecting methods, through following evolution:
- **1953-1960** discovery have been based on geophysical self-potential method and resistivity profiling for massive and shallow ore bodies, where redox phenomenon is developed.

- **1973-19**89- geophysical exploration was based on application of induced polarization, which was the main exploration method at the depth, and self-potential method and resistivity profiling for detalization and selection massive ore bodies from mineralization zones.

During the **phase of detailed exploration** have been applied: the induced polarization method, EM profiling, the radio wave floodlighting method, mise a la mase method, the borehole vectorial magnetic surveys, the electrical and gamma-gamma logging. In 1978, usefully was started developing of the IP/Resistivity "Real Section".

In Albania was gained a good experience for the integrated geological-geophysical-geochemical **exploration of chrome deposits** and were set up integrated methods to be used in ground and underground surveys. The geophysical methods have an important contribution for discovery in series of chromite deposits. Only during 1989 year, in the ultrabasic massif of Bulqiza were projected 356 boreholes to verify geophysical anomalies in 35 objects. From them, 145 boreholes have discovered mineralized horizons.

The geophysical complex for direct chromite deposit search includes surface mapping by gravity, magnetic and IP methods. Underground geophysical surveys were carried out for the search surrounding space of the mine works and boreholes. In order to get the geophysical documentation of the boreholes, have been performed electrical and radiation (density/selective gamma-gamma and neutron activation) logging.

For the search of chrome deposits, a further and continuous improvement is required to improve the coordination of the direct search for ore bodies with the geophysical methods used for geophysical-structural mapping and under-ground surveys. This is connected with the fact that petrophysical properties of the ore and those of surrounding rocks vary in a wide range, sometimes overlapping each other. All this factors have their influence on the effectiveness of the geophysical search for chrome ore bodies, which is lower than for copper ore bodies.

Through the exploration activity we learned in practice that the ores and surrounding rocks are characterized by unique value of the physical properties. The inverse is not true, i.e. the same magnitude of a physical property or feature may be the same for several minerals and rocks. For example, good electrical conductors are not only massive sulphides but kaolin and clays as well. Therefore, a single geophysical method and one physical feature of the medium are not sufficient to solve the problem. To find the solution is necessary to know the complex of different physical properties. Consequently, exploration has been integrated, with complex of the geophysical methods**.**

Perturbations caused by the topographic effect, variation of thickness and composition of the overburden beds, should be considered carefully to avoid false signals and spurious anomalies. To solve this problem, started from 1973 the application of mathematical methods and computer's data processing and interpretation.

Heights year's period was characterized by **e**xploration of copper sulphide massive and disseminated ore deposits, which are located at the depth up to 700-800 m. The main exploration method has been induced polarization method, and underground surveys. The increase of the depth of investigation has been supported by mathematical modeling.

These achievements were based on further methodological and organizational improvements organization of the geological-geophysical surveying in Albania. Complex geological-geophysical-geochemical teams for the search of copper deposits were created to carry out mappings at scale 1:5000 and detailed studies of anomalies at scale 1:2000. **This was the key of success.** The implementation of

geophysical methods in search for mineral resources, in general, and for mineral ore bodies, in particular, has been based also on methodological criteria: **moving from known areas toward unknown**, which made possible to discover the biggest copper fields in Albania, which consisted of 11 copper deposits, located at different topographic levels from surface down to depth of several hundred meters.

In the mid eighty's year's period there have been solved also two other problems:

- The discrimination of massive ore bodies in great depth, between mineralized zones.
- The discrimination of anomalies composed by the superimposed of the effect from the sulphide ore bodies and from the nearby serpentines individualization.

These complicated problems stand in front of search for all geophysicists of these days. To solve them we needed another improvement of the methodology of geophysical search, which started at the second half of the years eighty up to date.

After 1990 year up to present, geophysical exploration of the copper and chrome deposits with the minimal field volumes there are realized by foreign companies, which actually are worked in Albania.

2. ***Geophysical structural mapping*** *in the complex with geological mapping in order to recognize the geological settings of perspective zones and ore control factors.* The contribution of geophysical studies in the recognition of tectonic the zones and their relationship, is well known in Albania.

The gravity and magnetic mapping at scales between 1:25.000-1:200.000. A particular attention has been paid to petrophysical studies as well.

3. Development of the gravity and magnetic surveys

The development of magnetic and gravity surveys were performed in several directions:

- Expanding the field of use of gravity and magnetic methods for solid ores deposits exploration, including copper, chromium, and iron - nickel, bauxites, asbestos, heavy mineral placers.
- Study of magnetic properties and density of minerals and rocks.
- Building of the magnetic and gravitational country networks of Albania and their connection to international ones.
- The compilation of algorithms and standard software for processing and interpretation of magnetic and gravity data.
- The major results present the Bouguer Anomalies of the Gravity Field and Magnetic Field of Albania Maps, at the scale 1:200.000.
- Performing of the paleomagnetic studies in all Albanian territory, according to the bilateral projects Albania Austria, France, and Greece.

4. Radiometric studies and explorations

The first measurements of natural radioactivity in Albania, carried out in 1958-1959. Until 1990, radiometric studies and research have been secret.

Ninety years brought opening of radiometric research. Radiometric researches have applied to solve many important problems, which have not the relations with the Uranium explorations:

- Implementing radiometric gamma spectrometric determinations by radioactive elements U, Th, K, in the framework of an international project, and regional survey for Geochemical Atlas of Albania.

- Regional radiometric studies according to the total gamma radiation parameter. Has been realized the study "Natural Radioactivity of Albania."

Currently, radiometric studies are oriented to solving environmental problems.

5. Geothermal studies

Results of the geothermal studies and researches have been presented in the monographs: “Geothermy of Albanides” (1990), “ Geothermal Atlas of Albania” (1995), “Atlas of Geothermal Resources in Albania” (, 1996, published 2004), “Geothermal Atlas of Europe” (1992) published by Geographisch-Kartographische Anstalt Gotha, Germany, and “Atlas of Geothermal Resources in Europe”, European Commission (2002). Monograph “Geothermal energy resources in Albania and platform for their use”, published by Faculty of Geology and Mining, Polytechnic University of Tirana, (2010).

6. Seismological studies

Albania's seismological network was established in the period up to 1979, with fourteen stations in major cities of the country. During this period have been making Albanian seismological network part of the European and global network through the International Central Bureau of Seismology in Strasbourg, France.

Among major seismological study was conducted “Seismic Zoning Map of Albania” (1972), “Catalog of Earthquakes in Albania” (1975), and “Seismological Zoning of Albania” (1979), published by Academy of Sciences of Albania. Eighties years were period when spread massively seismological studies for solving engineering problems, realizing complex seismological- engineering and geotechnical engineering micro zoning of leading cities of the country.

Continued high levels of international cooperation on the problem of seismic risk the corner of the Balkans, in the event of the Assembly of European Council of Seismology, as well as in projects of UNESCO. Are conducted seven joint international projects and has collaborated on eight projects under the National Program for Research and Development for the publication of seismological, seismological-engineering, neotectonic and of the geological risks maps.

7. Forming of the geophysicist engineers and their post graduate qualification

Has given great contribution in development of the geophysics in Albanian by Section of Geophysics in the Faculty of Geology and Mining, Polytechnic University of Tirana in both directions: engineers forming, their postgraduate qualification, and scientific research.

Forming of geophysical engineers since 1961 and their postgraduate training was realized in the Branch of Geophysics, Section of Geophysics in Department of Earth Sciences, Faculty of Geology and Mining, Polytechnic University of Tirana. The period of study has been five years for engineers, taken 1-2 years (postgraduate school) and three years for doctoral studies. Current main course of applied geophysicist engineers have been exploration of the oil and gas reservoirs, other solid minerals deposits, hydrogeological research, engineering and environmental studies. During the period 1961-2008 are compiled and continuously improve the curriculum, they respond better to the requirements of time and level of scientific and technological research and geophysical studies and exploration.

In the Framework of implementing the Bologna Protocol, is closed Branch of Geophysics. Under the new curricula, after the first three years of common cycle (Diploma Bachelor for Georesources and Geoinformatics), a geophysical option is in

the second year of the Scientific Master degree. With this curricula, , as have been prepared in implementation of Bologna Protocol, results level landing of the scientific and professional formation of geophysical engineer.

In the Geophysical Branch have been formed 303 of engineering geophysics, and are specialized in geophysics and were re-qualified as geophysicists many physicist. Since 1962, Geophysical Brach was also conducted postgraduate qualification of 48 doctors of sciences.

1. Mining geophysics: Application of the new methods and technologies in Albania:

- Induced polarization method (1962 up to present)
- Micromagnetit surveys (1967)
- IP & RD Real section (1978 up to present)
- Increasing of depth of geophysical investigation (1984 up to present)

2. Mathematical and physical modeling for geoeelectric, gravity and magnetic methods, and inversion in geophysics. Compilation of the algorithms and software's for data processing and interpretation.
3. Extension of the application fields of geophysical methods for exploration of: chromite, asbestos, bauxites, heavy, rare and precious mineral placers, geotechnical and environment investigations, hydrogeological research, application of the natural electrical field for direct search of oil reservoirs.*5. Marine geophysics* (1974-1990): Design and construction of the marine geoelectrical station, marine vertical electrical sounding and profiling, and participation in performing of the marine integrated geological-geophysical studies of the Albanian Adriatic Shelf and design of deep wells for gas exploration in Durres Bay.
6. Regional geophysical studies: Geothermal (1989 up to present), Palomagnetic (1989-1997).

8. *Engineering and environmental geophysics* (1982 up to present), **Publication of the books:** The Section of Geophysics has completed all courses with textbooks, published in the period 1963-upo to present: 19 books for Branch of Geophysics, 4 books for Geological Branch and 5 monographs.

8. What shall we do further - as conclusions

Twenty last year's represent the period of expansion in the field of application of geophysical methods to solve the geotechnical tasks: soil and bedrocks study in the construction areas, control of the dams and landslides, hydrogeological explorations, micro zoning of the main cities in Albania, the study and evaluation of geothermal energy, etc. in Albania. Actually are taken the first positive results, first experience, as well as problems of the beginning.

Currently, the geophysical prospecting of oil and gas reservoirs, copper and chromium and other solid minerals deposits are suspended entirely by Albanian geophysical teams. Cessation of work and geophysical studies extremely serious consequences for future geological researches: The geological explorations remain free modern research methods, and turn to the thirty years of the last century level. With the termination of geophysical explorations, the teams were destroyed and lost a half century of their experience, well known also from prestigious institutions of advanced countries.

Today, for Albanian petrol and mining industries are important to take the proper development and implementation of Applied Geophysics directions in accordance with the requirements of market economy, for oil & gas and solid minerals explorations, using modern methods and surveys technology. At the same time, it is necessary to begin implementation of new technologies for geophysical surveys of shallow depths for solving of the geotechnical tasks, environmental control,

environmental impacts assessment, urban planning, water exploration, medical geophysics, archaeological sites searches, etc.

In response to the demands of time and development directions of the geophysics in the last two decades, there were worked successfully for the creation of Engineering and Environmental Geophysics in Albania. Geophysical methods have been applied in many fields: In-situ seismic and geoelectric topographies' for dams investigation, the slope stability evaluation and landslides study, soil and bedrocks study in construction and dam areas, of highways, tunnels, etc., for karst areas exploration, quality assessment of the concrete during construction works, and in the airport runway, water exploration, for study of the urban and industrial landfills, also for the assessment of the environmental impacts.Engineering and environmental studies are performed by the same methods, technologies, and equipments that are used for search of minerals. So, at the present, the geophysical and environmental engineering investigations are used the technology and equipment eighties years period, with exceptions when were working in the framework of European project. Albanian geophysical teams are necessary to obtain modern equipment to solve these new geological tasks, presented by today the market economy in Albania. In particular, this situation is very serious for the study of construction areas, of roads, the investigation of the hydrotechnic constructions like dams, the evaluation of the slope stability and landslides, the assessment of geological hazards, water exploration, etc.

For the forming of the yang geophysical engineers, currently the problem is the preparation and implementation of curricula and programs in accordance with the requirements of the Bologna Protocol, and actual scientific and technologic level of the geophysical methods. Future geophysicists should be able to realize the oil & gas, and solid minerals exploration because Albania is riche country with natural resources, in parallel is necessary to be able to solve also the engineering and environmental problems, applied surveys with modern technology and digital processing of data.

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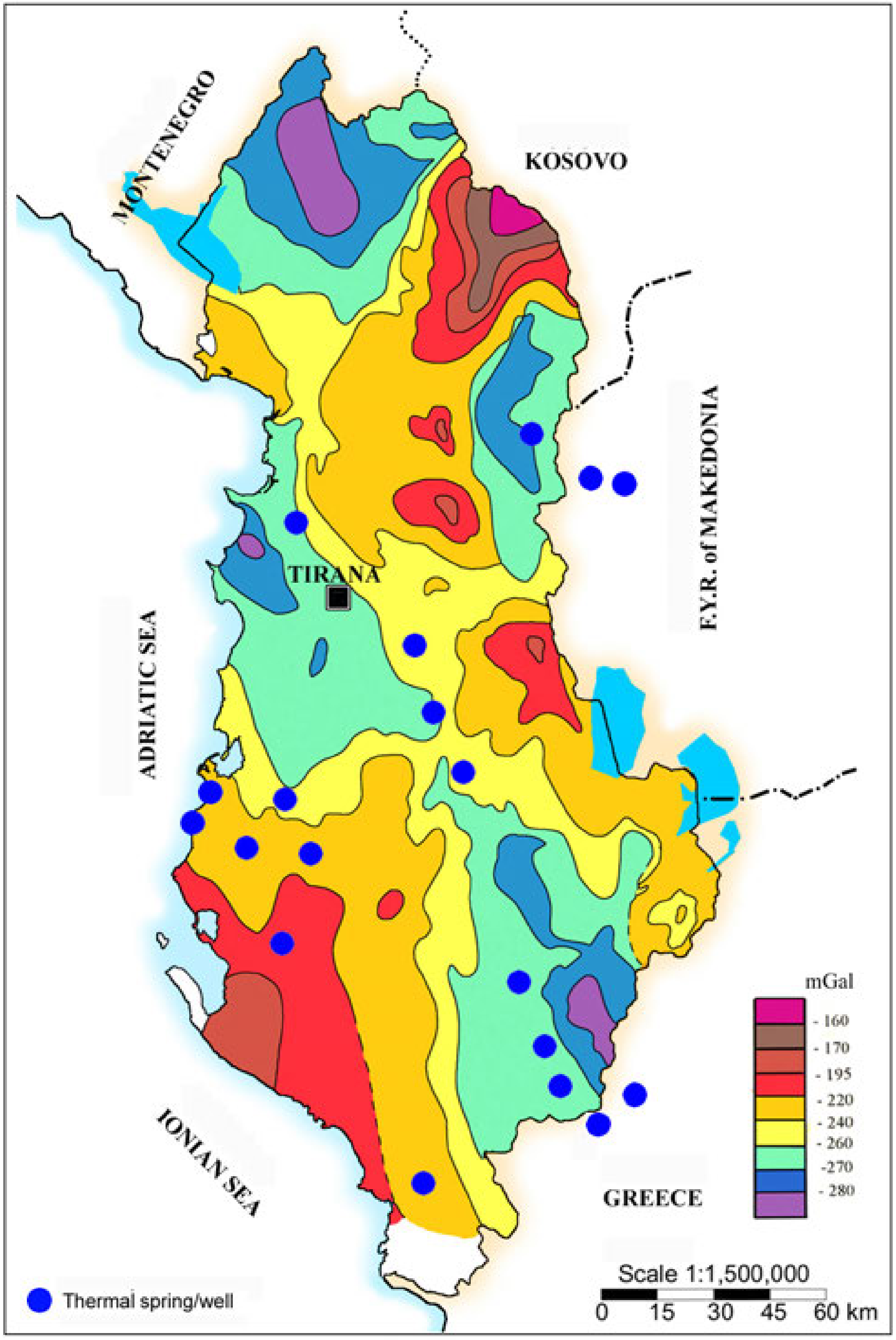
CASE STUDIES HISTORY

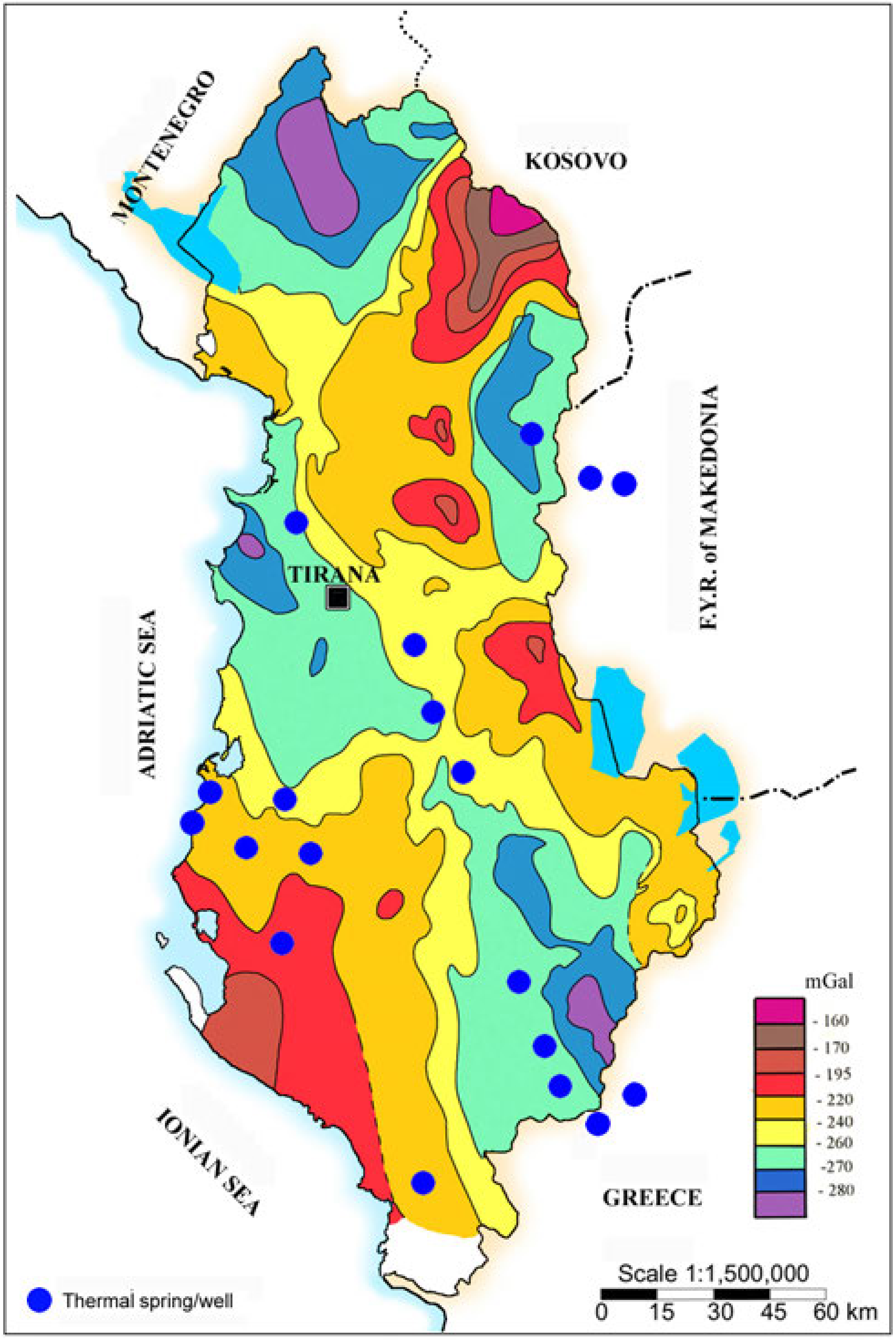
REGIONAL GEOPHYSICS



BOUGUER GRAVITY ANOMALIES MAP OF ALBANIA

(After Bushati S., 1988)

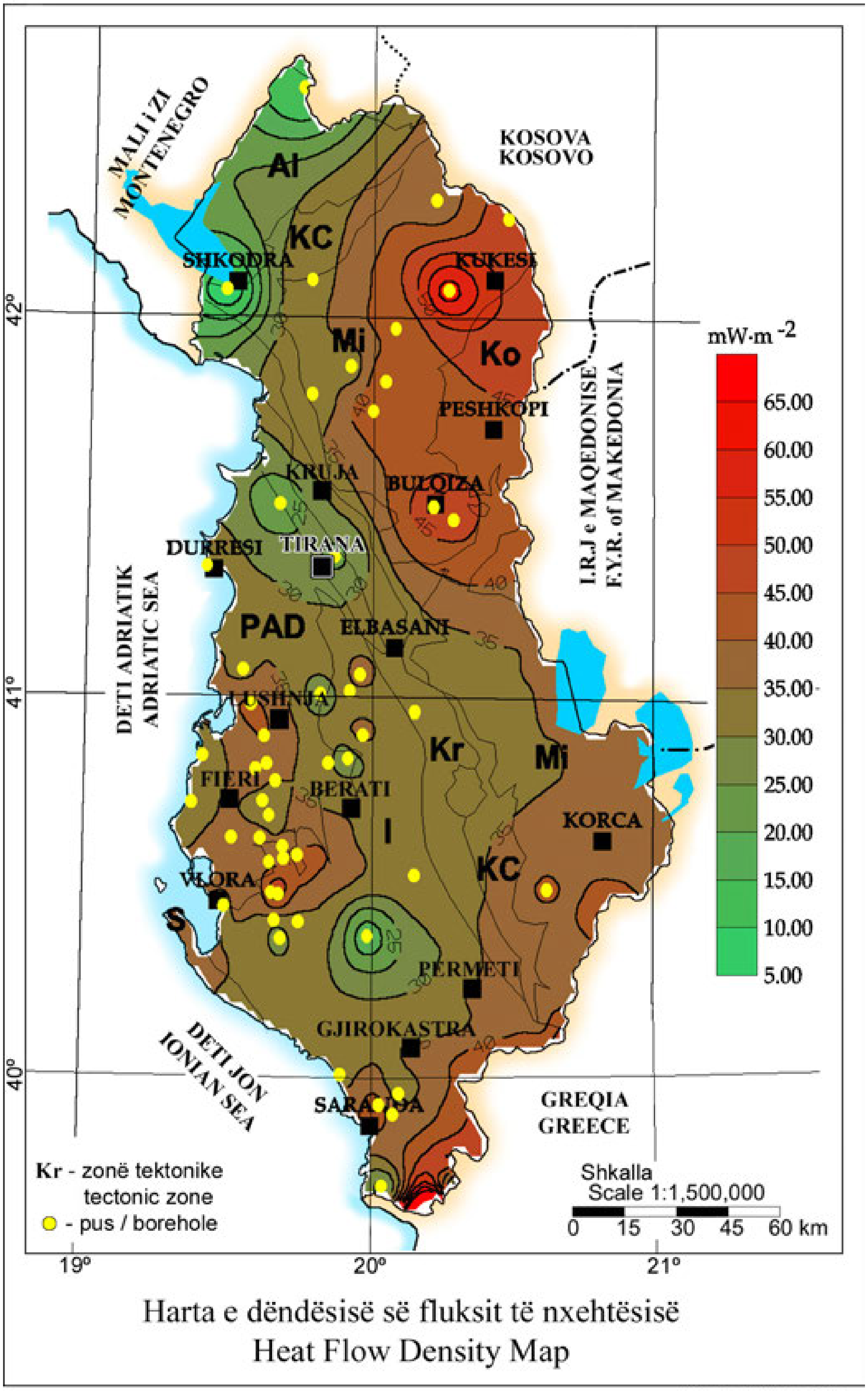
Fig. 1



BOUGUER GRAVITY ANOMALIES MAP OF ALBANIA

(After Bushati S., 1988)

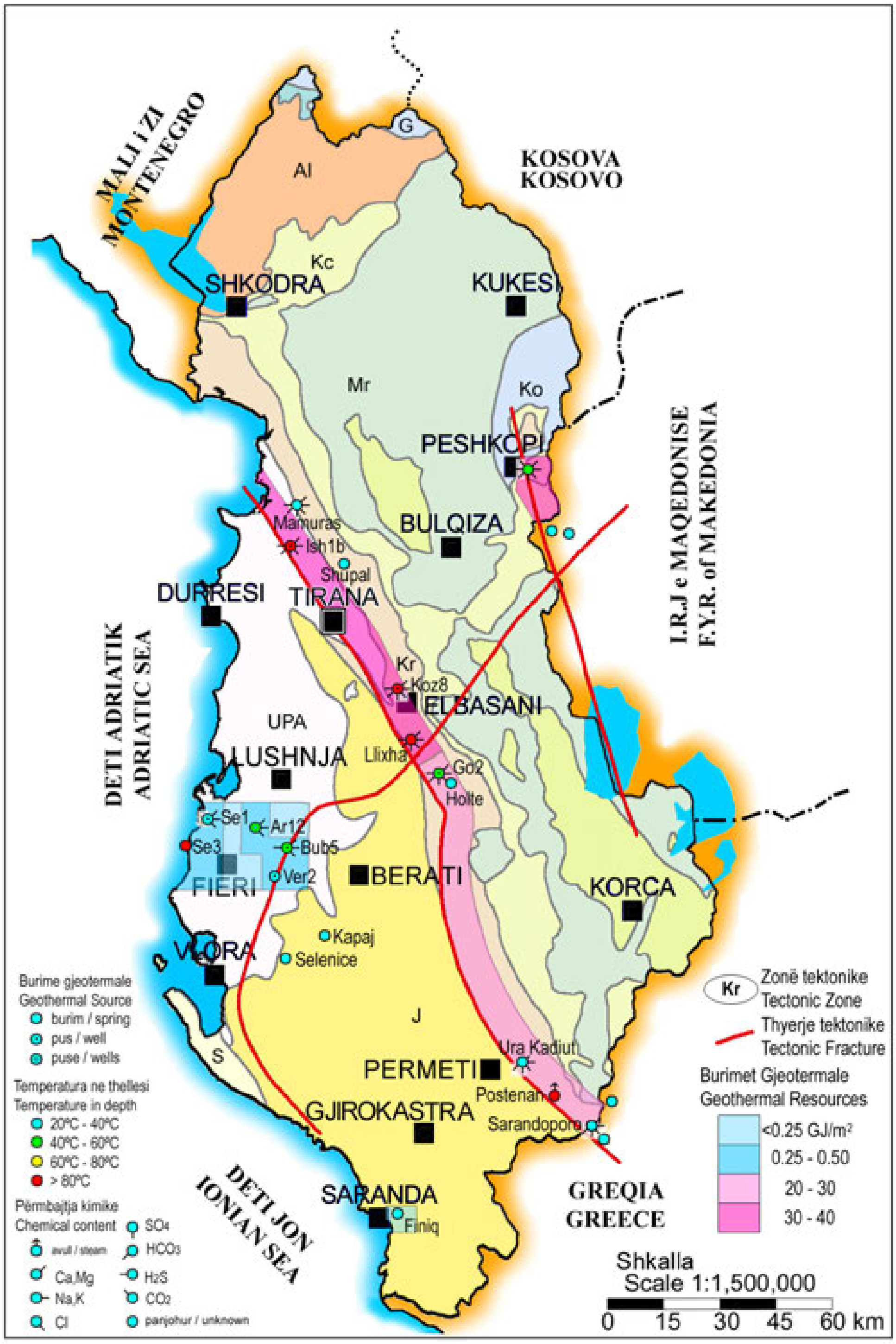
Fig. 1



Harta e dëndësisë së fluksit të nxehtësisë
Heat Flow Density Map

Fleta / Plate 16

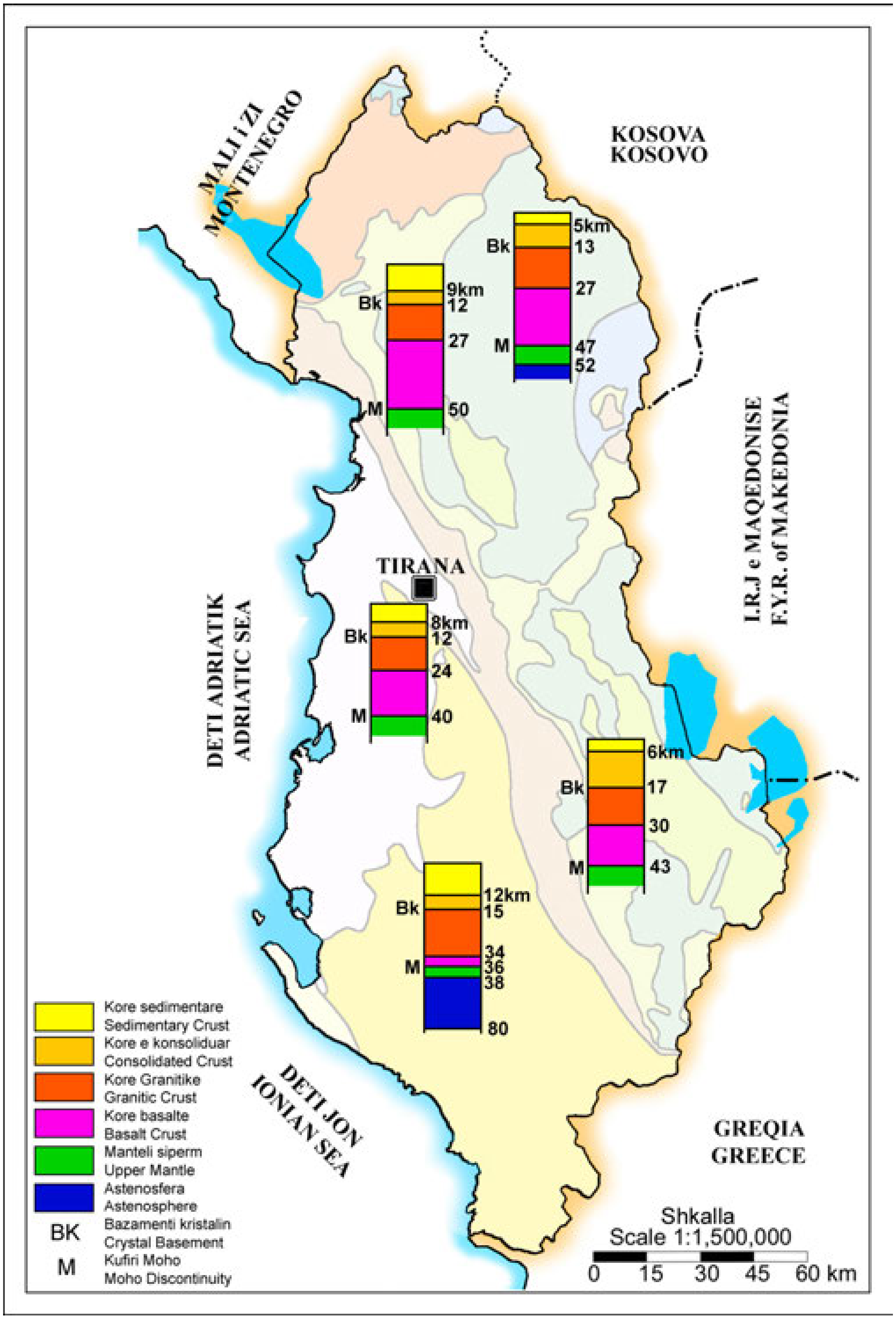
(After Frashëri A, Čermak V. et al. 1995)



Harta tematike gjeotermale
Geothermal Thematic Map

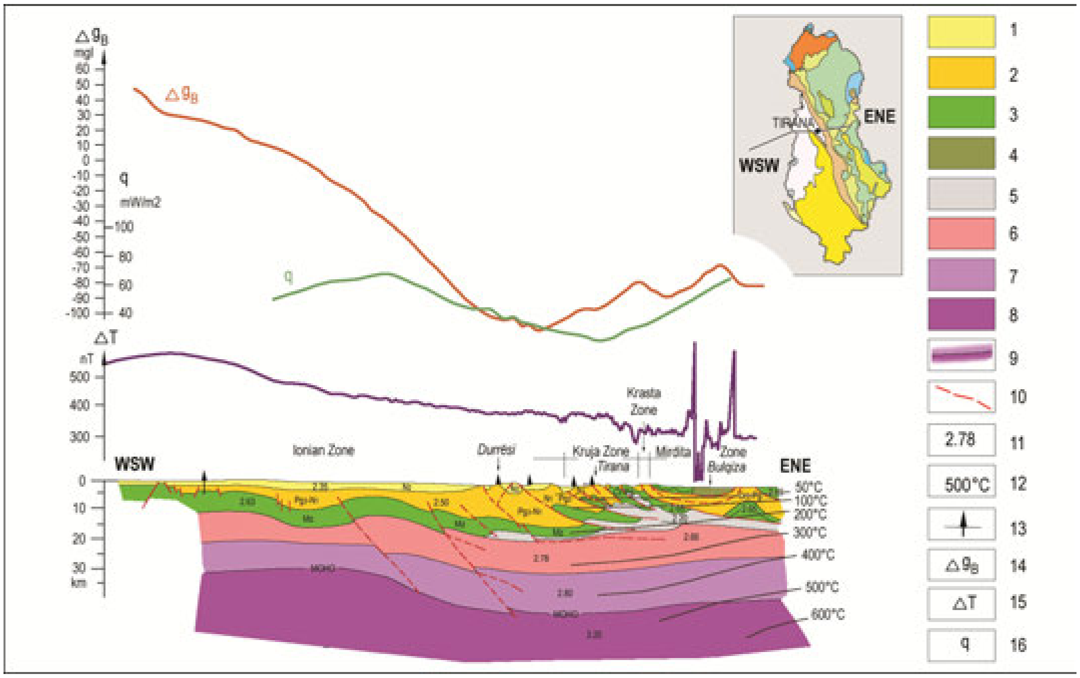
Fleta / Plate 17

(After Frashëri A, Čermak V. et al. 1996)



Geologic structure of Earth's Crust and Upper mantle based on seismological studies (data taken from Koçiu S. 1989).

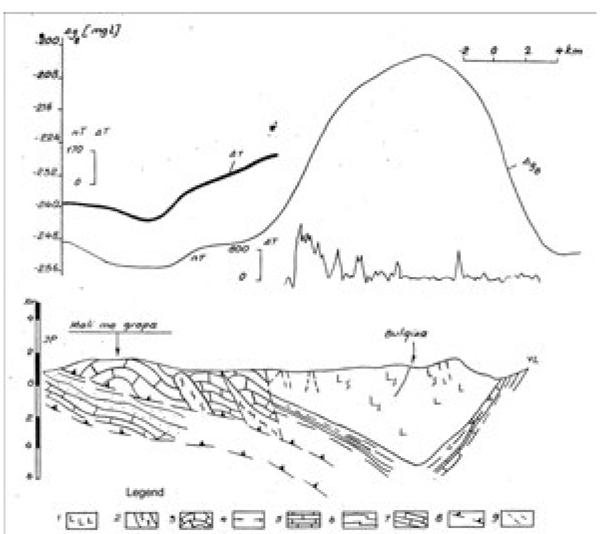
The numbers given in legen show the velocity of the seismic waves, in km/s). Sedimentary Crust; 2- Consolidated crust; 3- Granite Crust; 4- Basalt Crust; 5- Upper mantle; 6- Asthenospehere; 7- BK Crystal Basement; 8- Moho Discontinuity



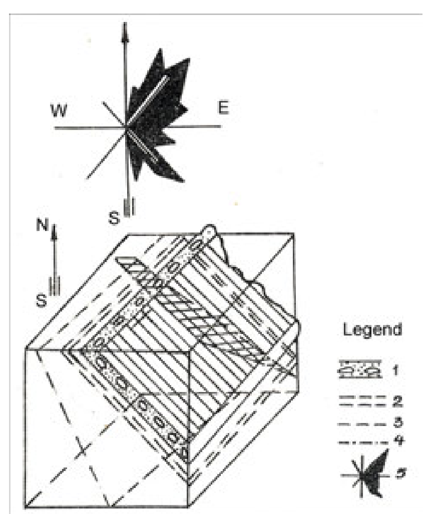
Geological-geophysical profile Albanid-2: Falco Adriatic Sea- Durres- Tirana- Peshkopi (The gravity data for the Adriatic Sea after Richetti, 1980)(Frashëri A. et al. 2002).

1. *Pliocene Sustratum; 2- Substratum of Serravalian Molasses; 3- Paleogenic flysch (Pg_3) and molasses over the limestone; 4- Flysch of the Mastrichtian ($Cr^{m}{}_{1}$), Lower and Middle Paleogene (Pg_{1-2}); Old flysch of Jurassic (J) and middle Cretaceous (Cr_2); 6- Carbonatic facies divided by the tectonic zones; 7- Ultrabasic rocks; 8- Disjunctive tectonic; 9- Depth up-rupt; 10- Top of chrystal basement; 11- The basal of the Earth Crust; 12- Moho Discontinuity' 13- Focus nodal plan of the earthquakes in the Kavaja region, western Albania; 14- Seismic reflection; 15- Deep well.*

$G_{B,t}$- Trend of 2nd degree of Bouguer anomaly; $G_{B,r}$- Residual Bouguer anomaly;
T_t - Trend of the 2nd degree of total magnetic anomaly; T_r - Residual of the 2nd degree of total magnetic anomaly; T_o - Observed magentic anomaly;



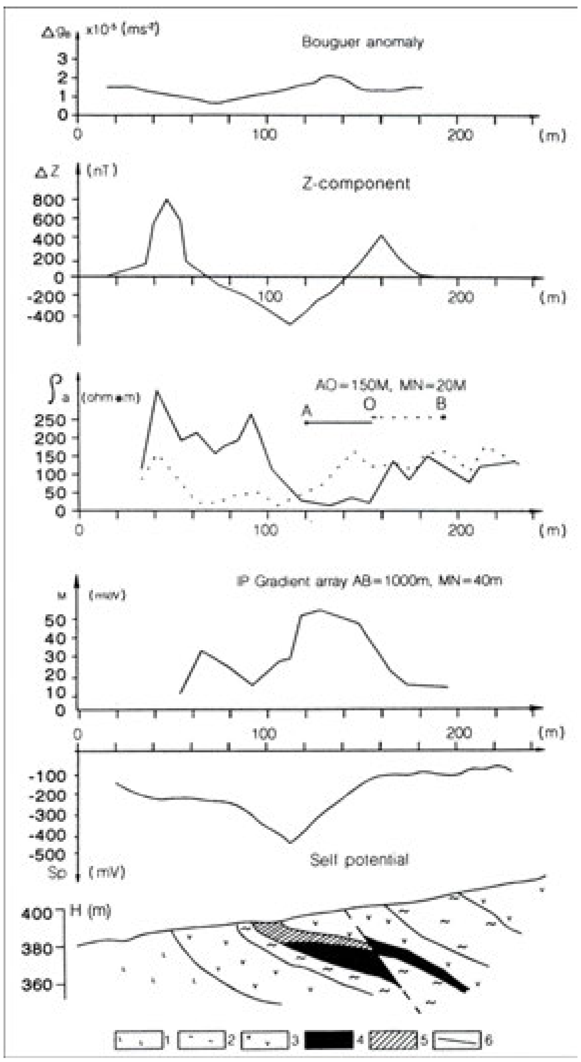
Bulqiza ultrabasic massif



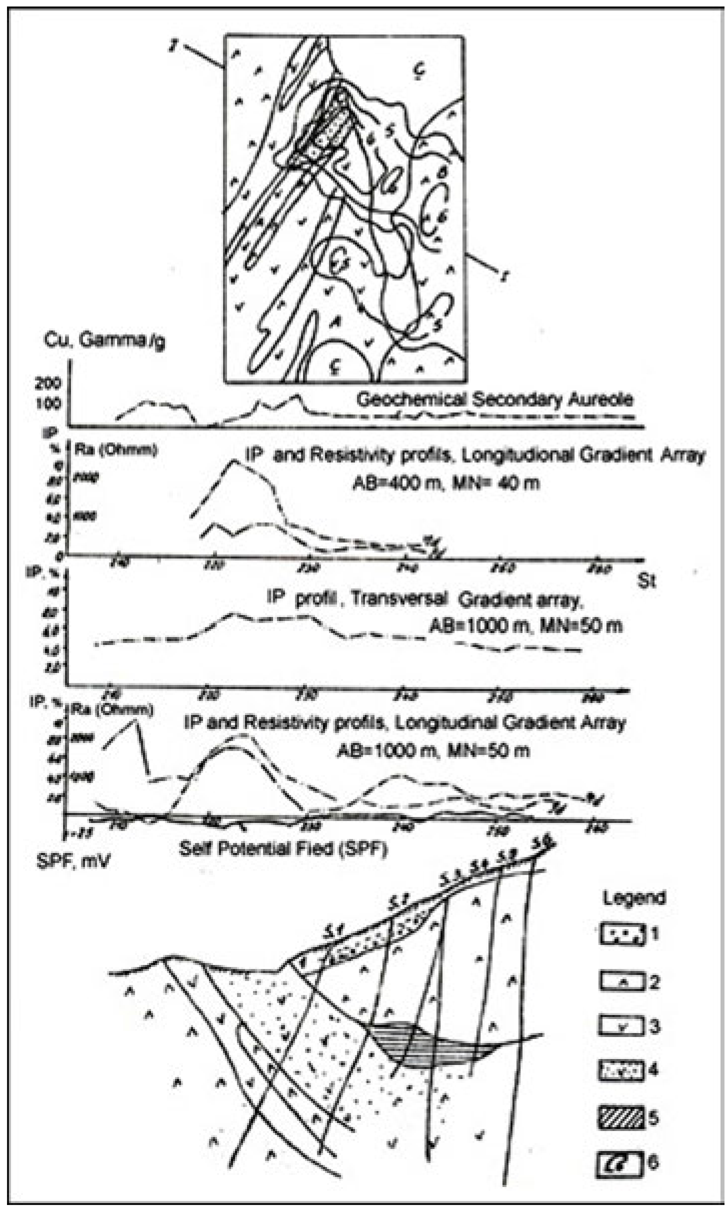
Micromagnetic surveys

MINING GEOPHYSICS

Copper deposits exploration

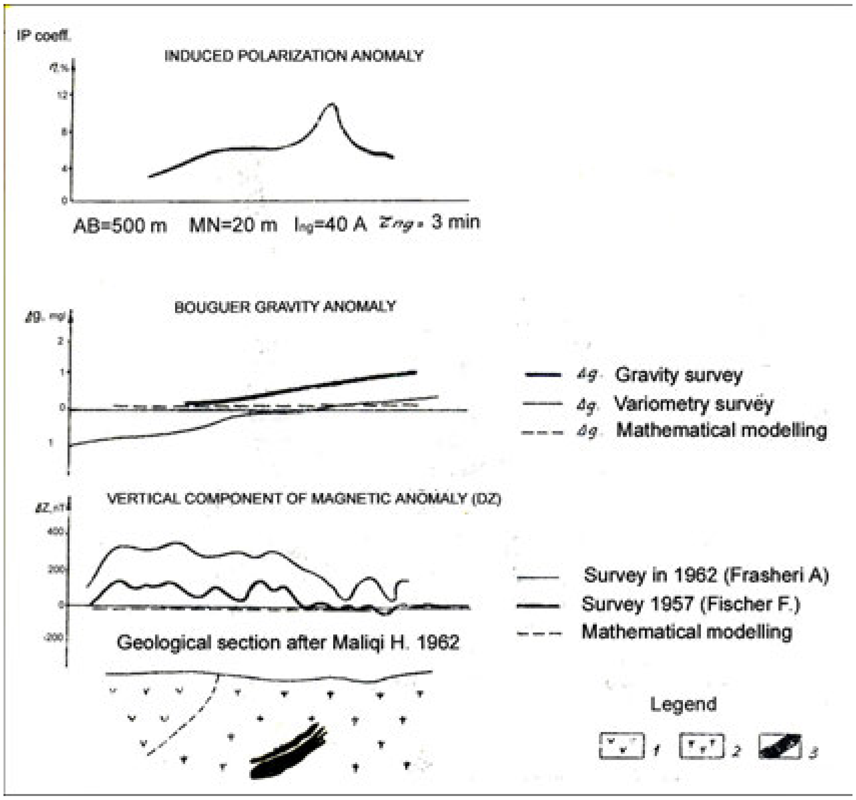


Gjegjani deposit
(Pogrebinsky S.A., 1961)

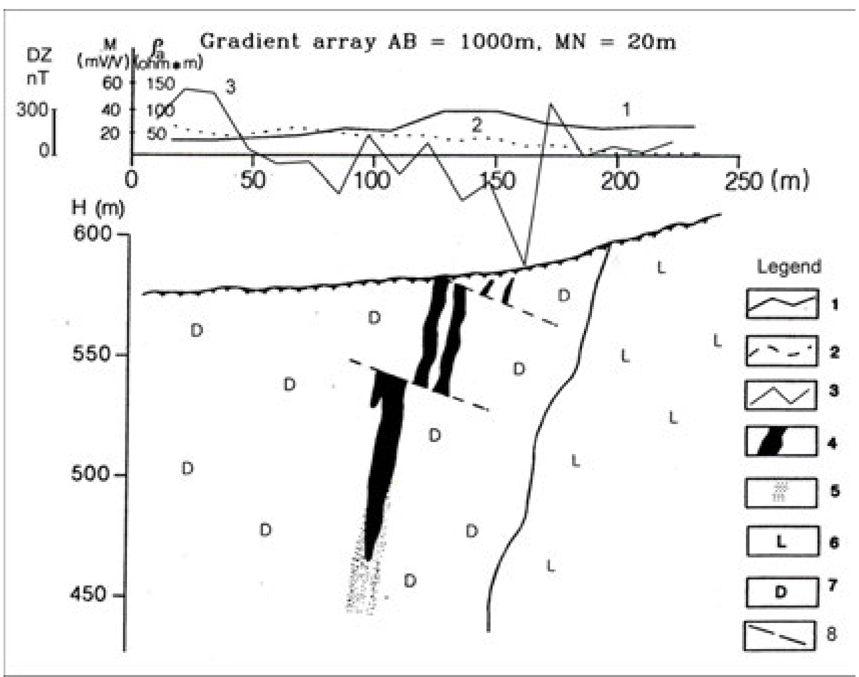


Qafa Barit deposits
(Frashëri A. 1961, Avxhiu R. 1973)

Chromite deposits exploration



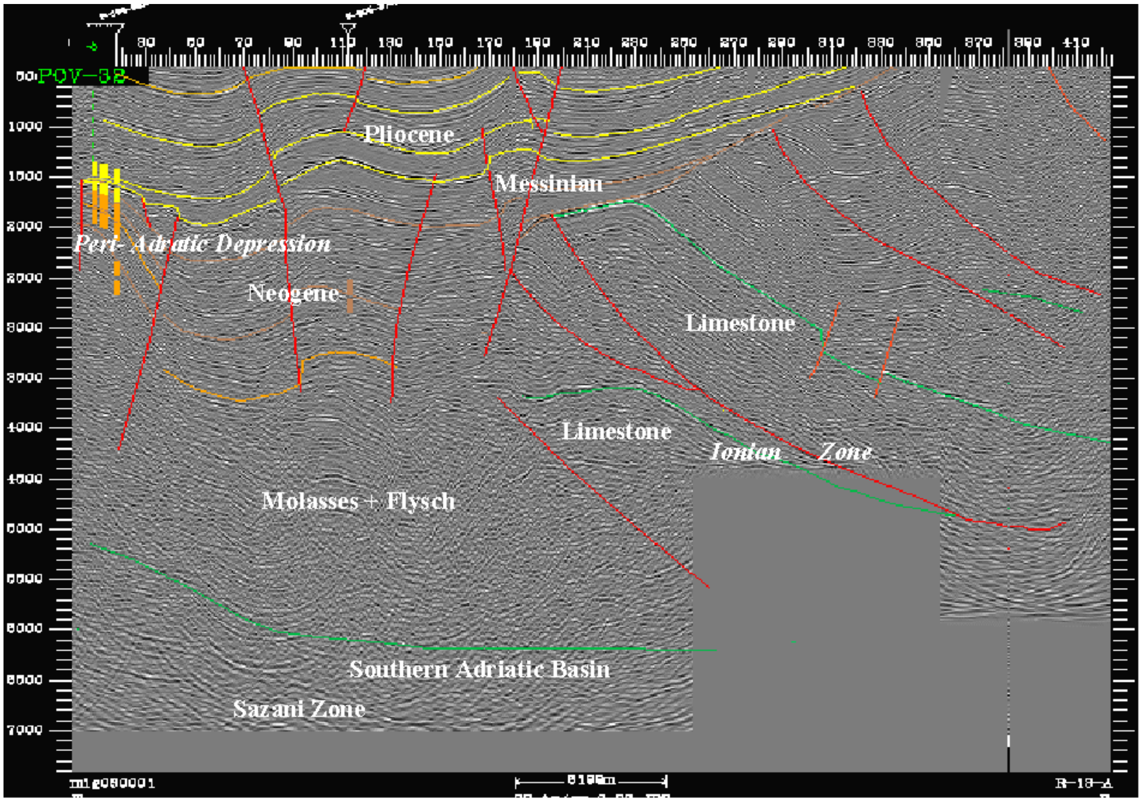
a)

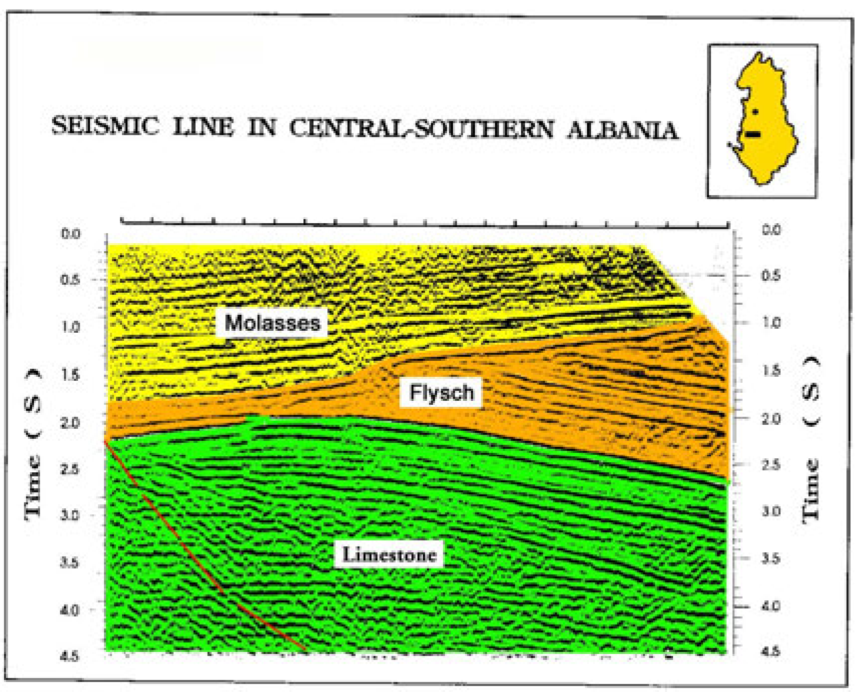


b)

Kam Tropoja deposit (a) ; Vlahna deposits (b) (Frashëri A., Lubonja L., 1962)

OIL AND GAS GEOPHYSICS





Seismic lines, Periadriatic Depression (Bare V. 2002)

ENGINEERING GEOPHYSICS

Dam invetigation

Qyrsaqi dam, Vau Dejes Hydropower Plant

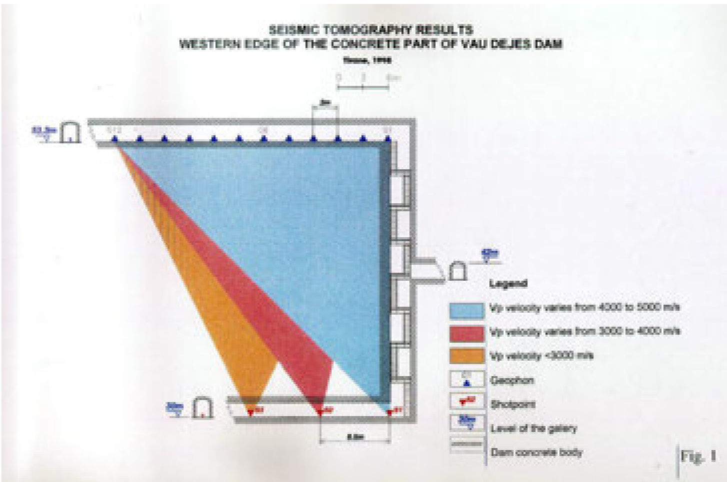
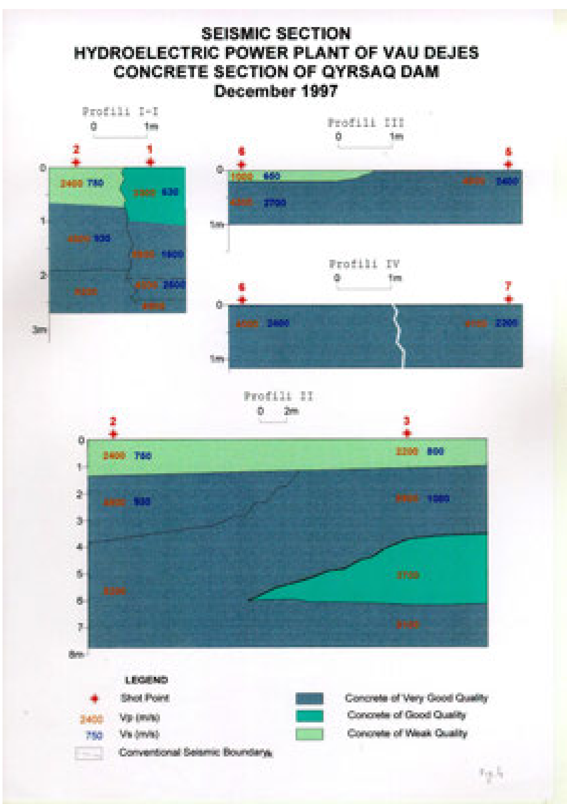


Fig. 1



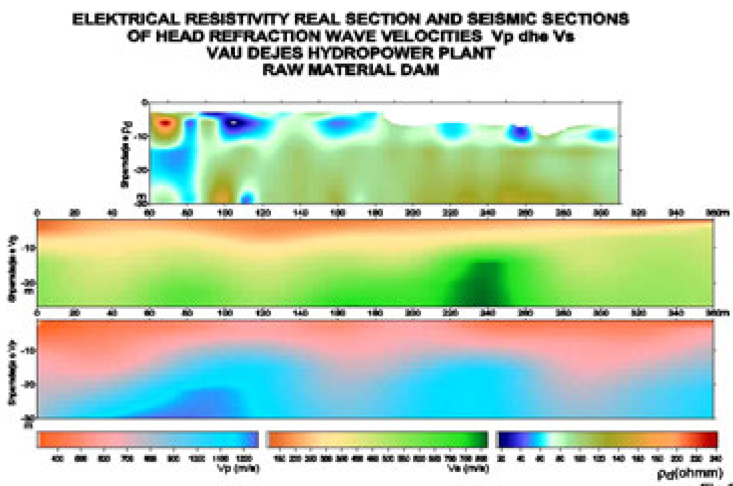
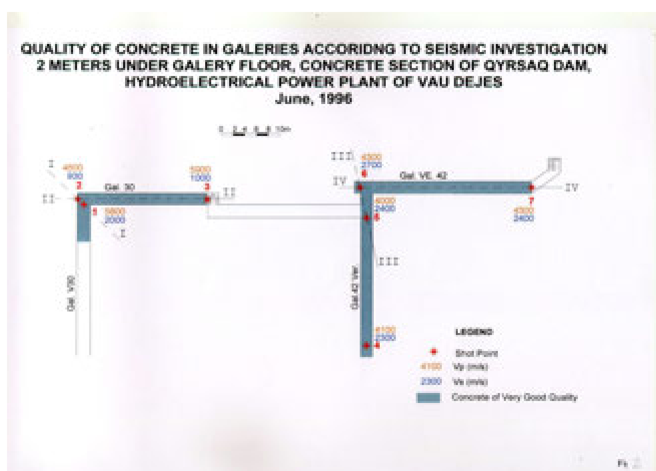
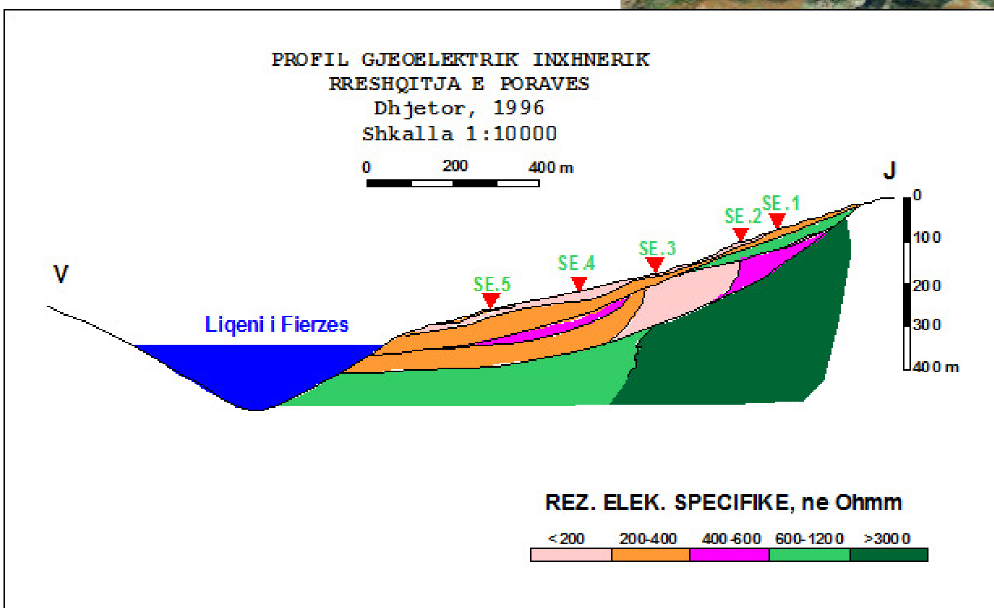


Fig.8

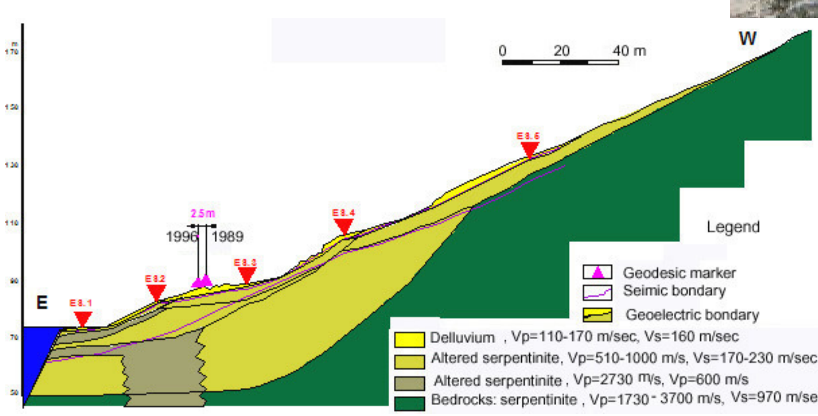


Lanslide investigation

Porava landlide, Fierza lakeshore



Ragami landlide, Vau Dejes lakeshore



SEG Annual Meeting and International Showcase

GLOBAL TEATER

17–22 October 2010 - Denver, Colorado USA

“Bolognia” Model and Geophysics in the Faculty of Geology and Mining

Alfred FRASHERI*, Salvatore BUSHATI**

- ***Faculty of Geology and Mining**
- **** Academy of Sciences of Albania**

Section of Geophysics has given great contribution in development of the geophysics in Albania in two directions:

- Engineers forming, their postgraduate qualification, and
- Scientific research.

Forming of geophysical engineers since 1961 and their postgraduate training was realized in the Branch of Geophysics, Section of Geophysics in Department of Earth Sciences, Faculty of Geology and Mining, Polytechnic University of Tirana.

The period of study has been **5 y.** for **Engineers**, **1-2 y, Master**, and **3 years PhD**. for:

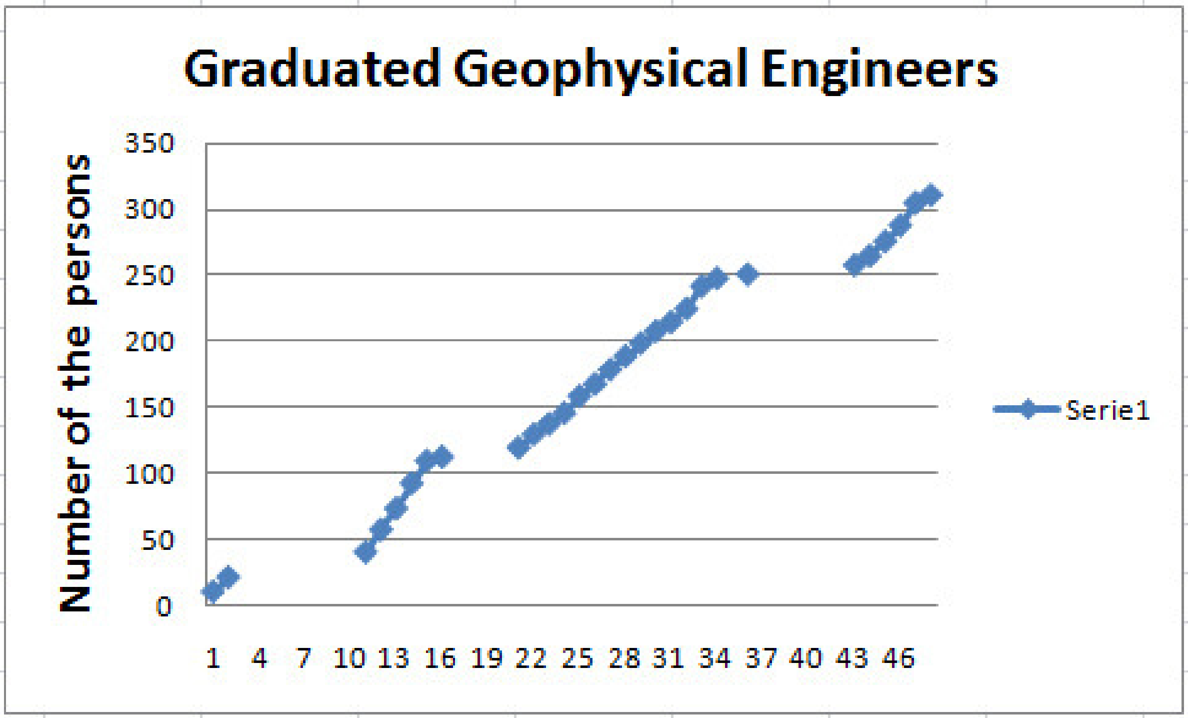
- exploration of the oil and gas reservoirs,
- exploration solid minerals deposits,
- hydrogeological research,
- engineering and environmental studies.

In the Framework of implementing the Bologna Protocol, is closed **Branch of Geophysics.**

Under the new curricula after **Bachelor Diploma** for Georesources and Geoinformatics – (**3 years**), **Scientific Master degree in Geophysics**, through option in the second year of the second cycle.

With this curricula, as have been prepared in implementation of Bologna Protocol, results level landing of the scientific and professional formation of geophysical engineer.

CONTRIBUTE OF THE FACULTY OF MINING FOR DEVELOPMENT OF THE GEOPHYSICS IN ALBANIA



GRADUATED PERSONS

Engineer Geophysicists 304

Dr. Sc. 45 **Research Leaders 9**

Professors 7 Prof. Ass. 1 **Research Masters 12**

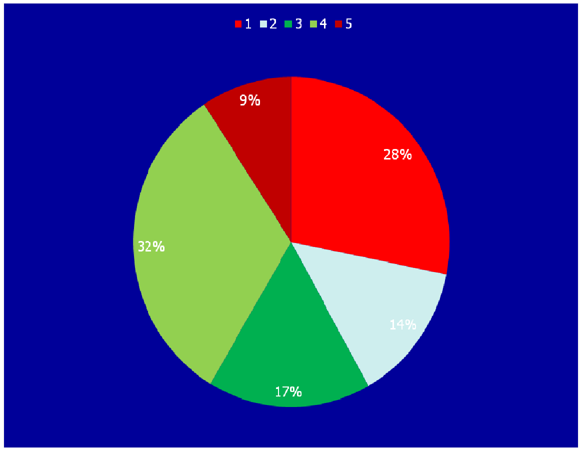
Improvement of the geophysical knowledge over the years

	1961-1964	1973-1978	2002-2005
Magnetic surveys	+	+	+
Gravity surveys	+	+	
Geoelectrical Exploration	+	+	+
Waves theory-seismics	+	+	+
Wave theory- seismics-seismology			+
Stratigraphic seismics			+
Engineering seismic s			+
Well logging	+	+	+
Radiometry	+	+	+
Signal processing			+
Physics of the Earth		+	+
Data processing and interpretation		+	+
Engineering geophysics			+
Environmental geophysics			+
Mining Geophysics			+
Geothermics			+

Improvement of the mathematical knowledge over the years

	1961-1964	1973-1978	2002-2005
Mathematic Analyzes	+	+	+
Analytic Geometry	+	+	+
Special Fis. Math. Equations and special functions	+	+	+
Linear Algebra		+	+
Statistics and Probability		+	+
Geostatistics			+
Informatics Programing		+	+
Numerical Analyzes		+	+

5 YEARS SYSTEM EGINNERING: GEOPHYSICAL ENGINEER, 2000-2004

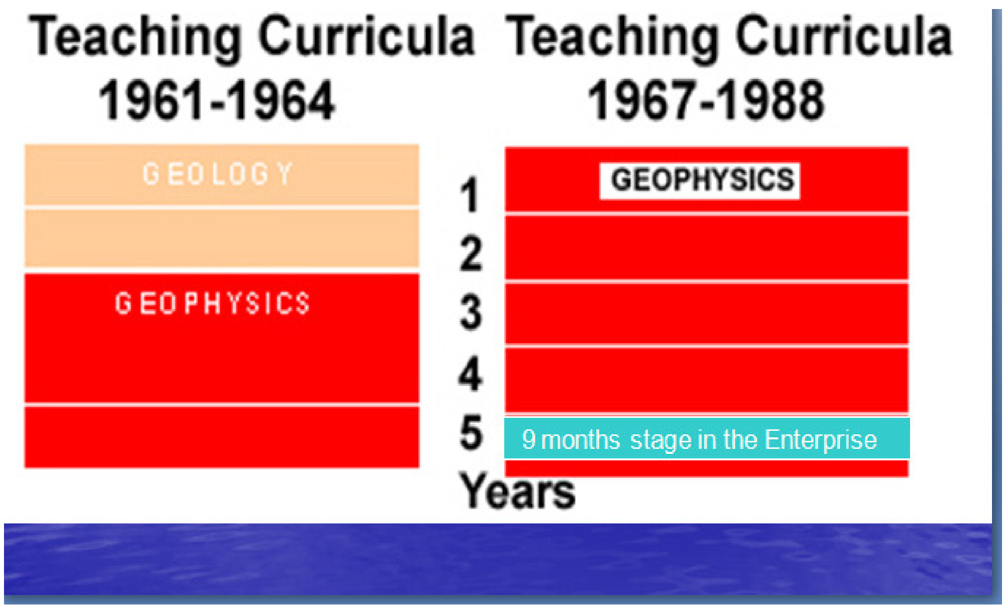


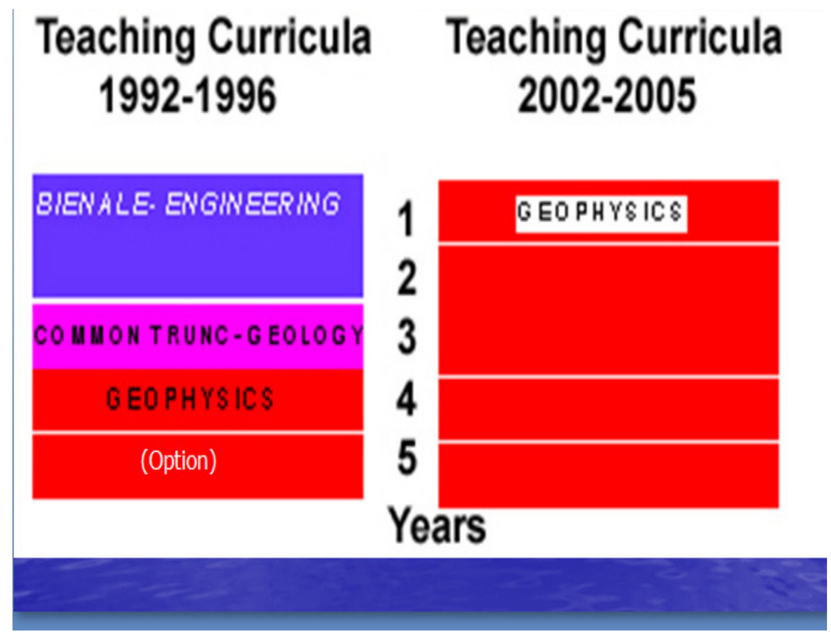
DISCIPLINES: 1. Theoretical; 2. Engineering; 3. Geological; 4. Geophysical; 5. Social

Teaching Curricula- Geophysical Branch (2000-2004)

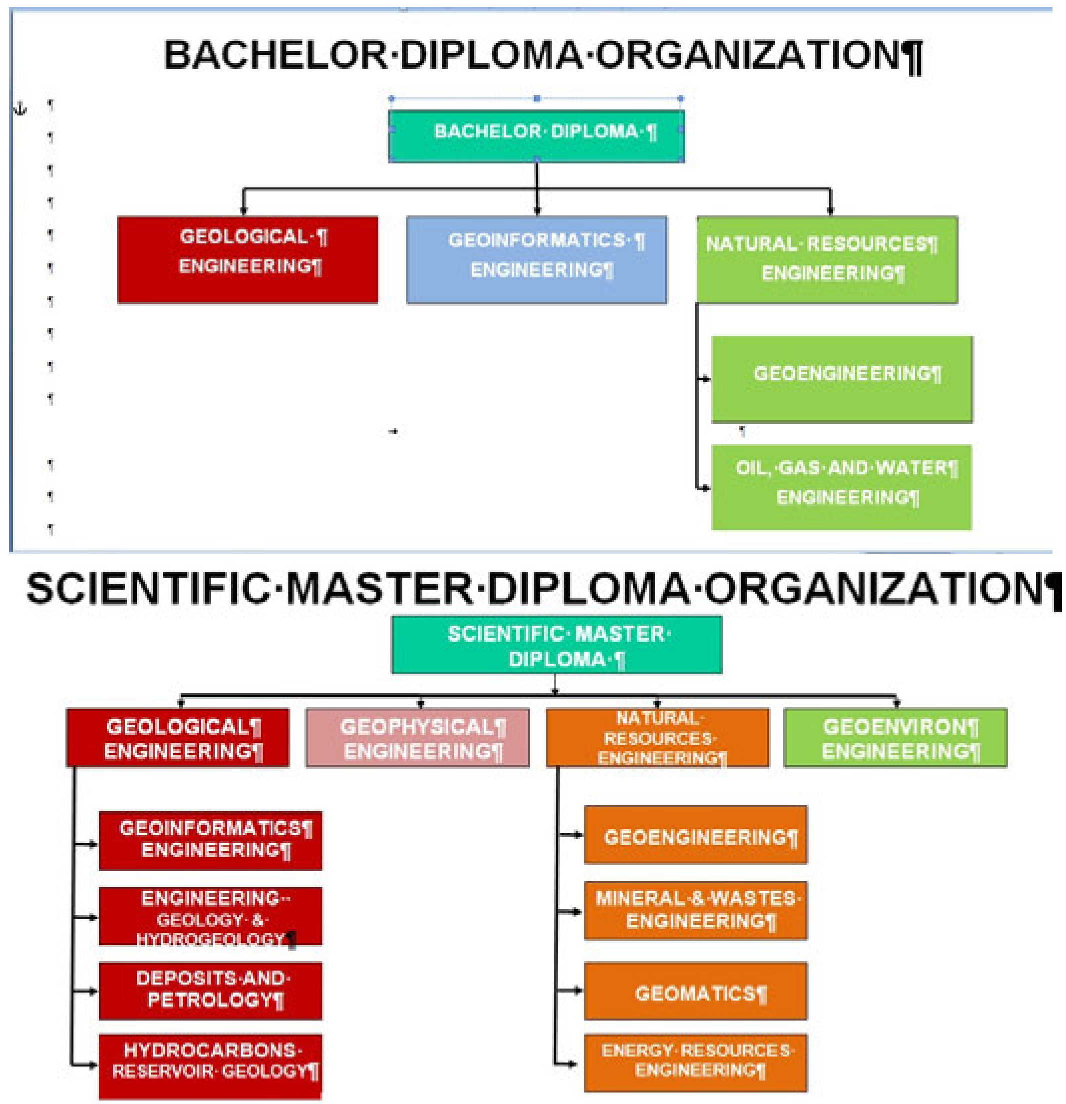
Nr	Discipline	Hours	Nr	Discipline	Hours
	Social disciplines			**Geological disciplines**	
1	Sociology	45	25	General geology	75
2	Physical educate	120	26	Paleontology, stratigraphy, historical geology	60
3	Foreign language	240	27	Geomorphology and Quaternary Geology	36
	Theoretical base disciplines		28	Mineralogy, petrography	120
4	Albegra and analytic geometry	120	29	Structural geology and geotectonic	111
5	Mathematical and numerical analyziz	330	30	Geology of solid deposits and their exploration	120
6	Statistics and probability	75	31	Petroleum geology and	144
7	Special equations of the physical mathematics	70	32	Hydrogeology and engineering geology	60
10	Informatics	120		**Geophysical disciplines**	
11	Geostatistics	48	33	Gravity survey	105
12	Physcs	255	34	Magnetic survey	91
13	General and physical chemistry	120	35	Geoelectrical survey	196
14	Signal Processing	90	36	Waves theory, seismic and seismology	274
	Engineering disciplines		37	Well logging	194
15	Geodesy and markshaidery	75	18	Nuclear geophysics and radiometric survey	133
16	Descriptive geometry and technical design		19	Physic of the Earth	60
17	CAD	45	20	Market economy basis	60
18	Engineering graphics	135	19	**Optional disciplines**	70
19	Theoretical and engineering mechanics	120	20	Problems of the geophysical explorations	
21	Electrotechnic and applied electronic	90	21	Problems of the reservoir study	
22	Geoinformative systems (GIS)	60	22	Geoengineering geophysics	
23	Mining and drilling technologies		23	Undeground geophysical survey	
			24	Environmental Geophysics	
				Total	**4363**
				Field practice	9 weeks

EVOLUTION OF THE TEACHING CURRICULA OVER THE YEARS





GEOPHYSICS IN THE FACULTY OF GEOLOGY AND MINING IN FRAMEWORK OF THE BOLOGNA MODEL

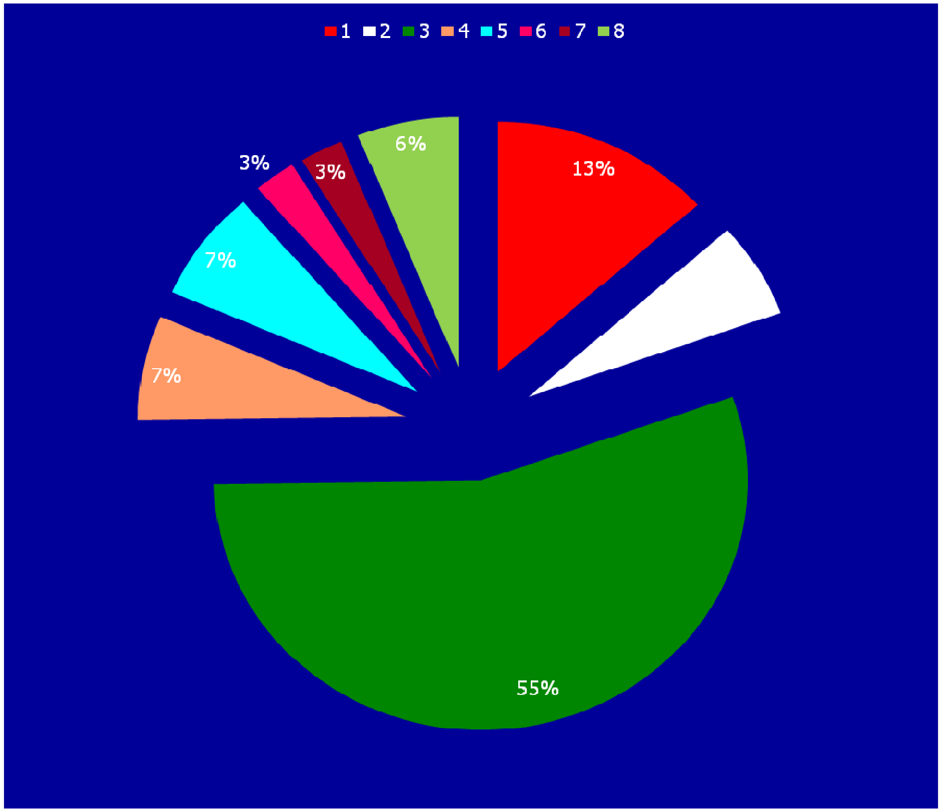


BACHELOR DIPLOMA

GEOLOGICAL ENGINEERING

I YEAR	Disciplines	ECTS	Hours
1	Chemistry 1+2	**8**	102
2	Mathematic 1+2	**8**	102
3	Technical design + CAD	**4**	43
4	Geomatic	**4.5**	54
5	Physics 1+2	**9**	114
6	General Geology	**3.5**	48,5
7	Mathematical Statistics	**5**	63
8	Informatics	**5**	63
9	Paleontology – Historical Geology	**5**	77,5
10	Chrystalographyi + Chrystalochemistry	**3**	34,5
11	Foreig Languege	**5**	66
Total		**60**	**768**
II YEAR			
12	Paleontology – Historical Geology	**5.5**	70
13	Optical Mineralogy	**4.5**	74
14	General Mineralogy + systematics + Methods	**6.5**	22
15	Petrology + Magmatic Petrography	**8.5**	155,5
16	Sendimentary ande metamorphic Petrography	**5**	82,5
17	Mechanic + Resistance of the materials	**4.5**	58
18	Sedimentology + Marine Geology	**7.5**	103,5
19	Stratigraphy	**4.5**	73,5
20	Geological Mapping	**6.5**	113
21	Structural Geology	**7**	103
Total			
III YEAR			
22	Mechanic of medium continue	**4**	52
23	Geochemistry basis + environmental geochemistry	**7**	90
24	Applied Geophysics	**10**	152
25	Techtonic	**5**	64
26	Hydrogeology	**4**	52
27	Sedimentary Basins + Hydrocarbon reservoirs	**4**	52
28	Metallic Deposits, Econimical Minerals	**6**	82,5
29	Regional Geology	**6**	78
30	Rocks and Soil Mechanics	**3**	38
31	Drilling and Mining Geotechnology	**6**	78
32	DIPLOMA	**5**	0
33	GIS and themai mapping	**6**	78
34	Environmental Geochemistry and hydrochemistry	**4**	52
Total		**60**	**739**
	TOTAL for BACHELOR DIPLOMA GEOLOGICAL ENGINEERING	**180.00**	**2321.0**

BACHELOR GEOLOGICAL ENGINEERING DIPLOMA



Matematike-Fizike; 2- Kimi; 3- Gjeologji; 4- Lende teknike specialiteti; 5- Lende te pergjitheshme teknike; 6- Informatike; 7- Gjuhe e huaj;

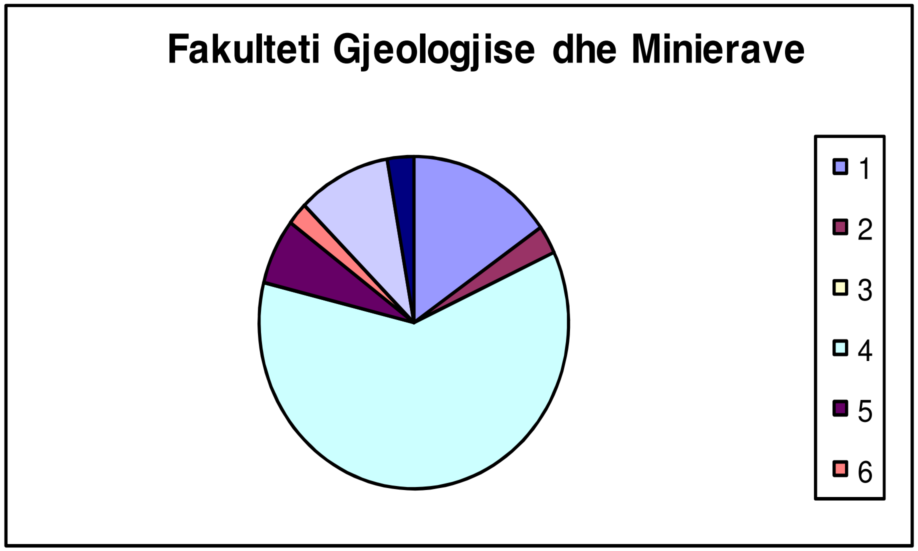
1. 8- Gjeofizike

SCIENTIFIC MASTER DIPLOMA
GEOLOGICAL ENGINEERING
Speciality: GEOPHYSICAL ENGINEERING

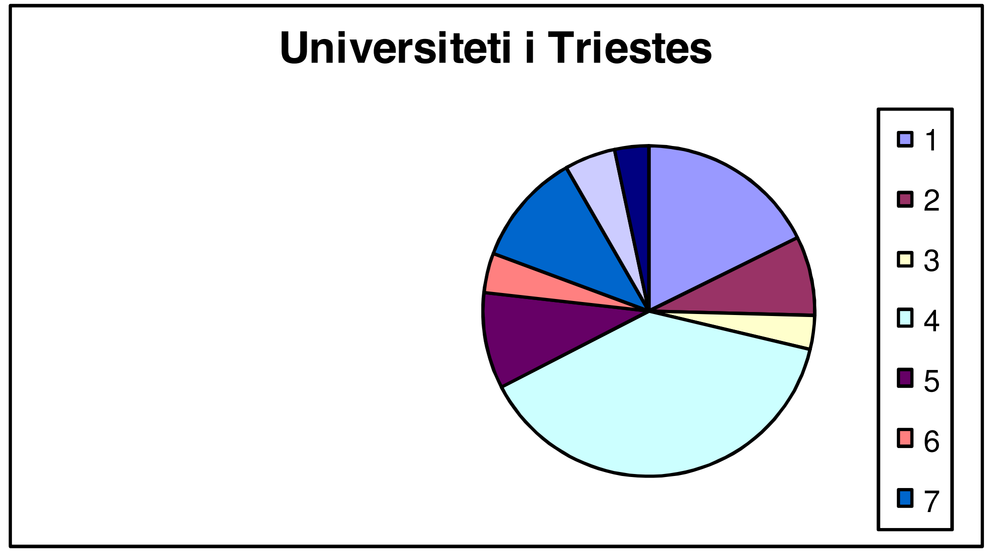
Nr.	DISCIPLINE	ETC	HOURS
I YEAR			
1	Electrotechnic &Electronic	4	48
2	Topography & GIS	4	54,5
3	Addendum in mathematic	11	121
4	Potential fields	11	140,5
5	GeoelectricAL method	13	172
6	Theory of vawe's scattering & seismology	10	108,5
7	Seismic of reflected and refracted vawes 1	7	96
Total		**60**	**644,5**
II YEAR			
8	Seismic of reflected and refracted vawes 2	7	96
9	Nuclear physics and radiometry	7	80,5
10	Well logging	10	98,5
11	Digital processing and stratigraphic seismic	10	108,5
12	Geology of natural reservoirs	5	54
13	Optional discipline: - Geophysics of natural resources - Engineering and Environmental Geophysics e	6	62,5
Total		**50**	**311**
	TOTAL for Scientific Master on Geophysics	**110**	**955,5**

COMPARISON OF THE TEACHING CURRICULA
EARTH SCIENCES BACHELOR DIPLOMA

FACULTY OF GEOLOGY AND MINING



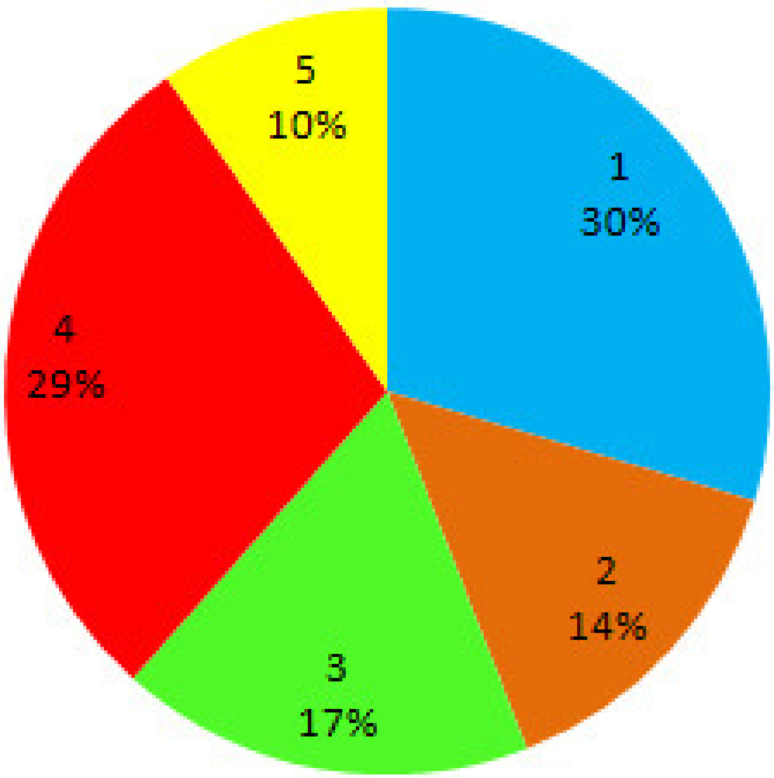
TRIESTE UNIVERSITY

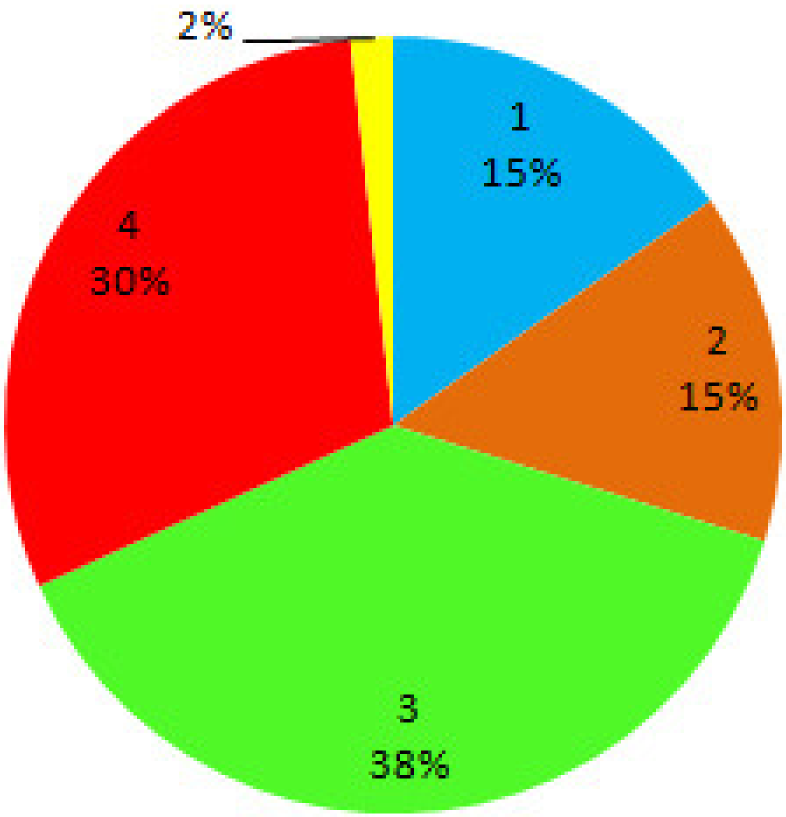


DISCIPLINES: 1- Theoretical; 2- Engineering; 3- Nature; 4- Geological; 5- Geophysical; 6- Social; 7- Indipentent work; 8-Stage; 9- Diploma

COMPARISON OF THE TEACHING CURRICULA

5 YEAR SYSTEM 2000-2004 | **BOLOGNA MODEL 2007-Now**





DISCIPLINES: 1. THEORETICAL; 2. ENGINEERING; 3. GEOLOGICAL 4. GEOPHYSICAL; 5. SOCIAL

Result that in the Framework of implementing the Bologna Protocol:

is closed Branch of Geophysics.

Under the new curricula, after the first three years of common cycle:

(**Diploma Bachelor for Georesources and Geoinformatics**),

a **geophysical option** is in the second year of the **Scientific Master degree.**

With this curricula, , as have been prepared during the implementation of Bologna Protocol, results level landing of the scientific and professional formation of geophysical engineer.

TEACHING STRUCTURE

Learning process is developed by giving of the proper importance to all its elements:

- **1. Lectures,**
- **2. Practical lessons: a) The laboratory,**
  b) Seminars,
  c) Solutions of exercises and project courses,
  d) In the field,
- **3) Project diploma courses.**

UNIVERSITY TEXT BOOX
19 books for Branch of Geophysics, 4 books for Geological Branch (in Albanian) University Publishing House, Tirana.

Geophysical Branch:

- **Gravity Surveys, Exercises**
- **Magnetic Surveys, adoption**
- **Electrical Exploration**
- **Electrical Exploration, Exercises**
- **Waves Theory**
- **Seismic Exploration**
- **Well logging**
- **Radiometry**
- **Geophysical method application for solving of the geological problems**
- **Physical properties of the minerals and rocks**
- **Geophysical Equipment**
- **Some equipment for the direct current geoelectrical surveys**

Geological, oil and Gas Engineers, Minig Engineers

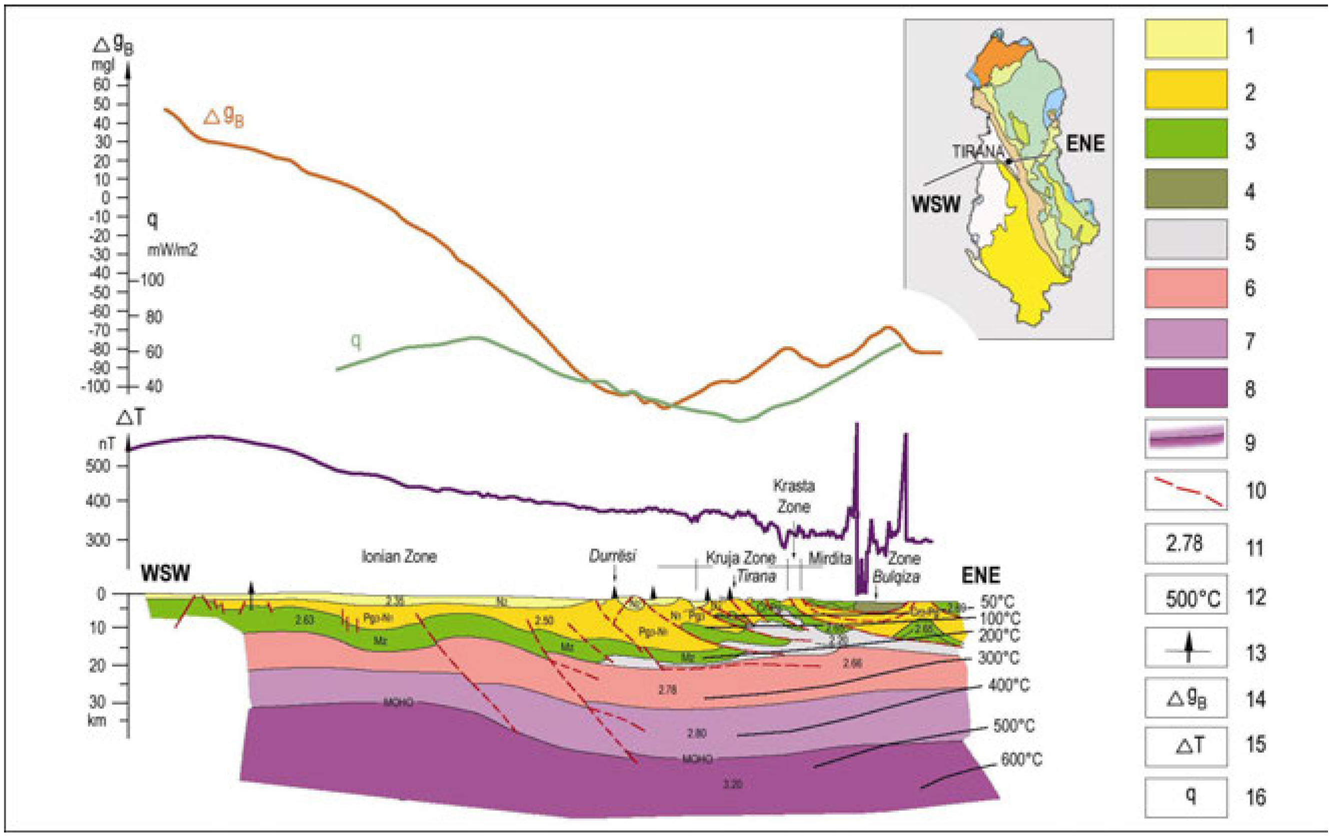
- **Applied Geophysics: v. 1. Gravity**
  v. 2. Magnetics
  v. 3. Geoelectrical Methods
  v. 4. Seismics and Radiometry
- **Well logging**
- **Geophysical Methods for solving of the Mining Problems**

Thank you very much for your attention!

Section of Geophysics has given great contribution in development of the *geophysical scientific research* in Albania:

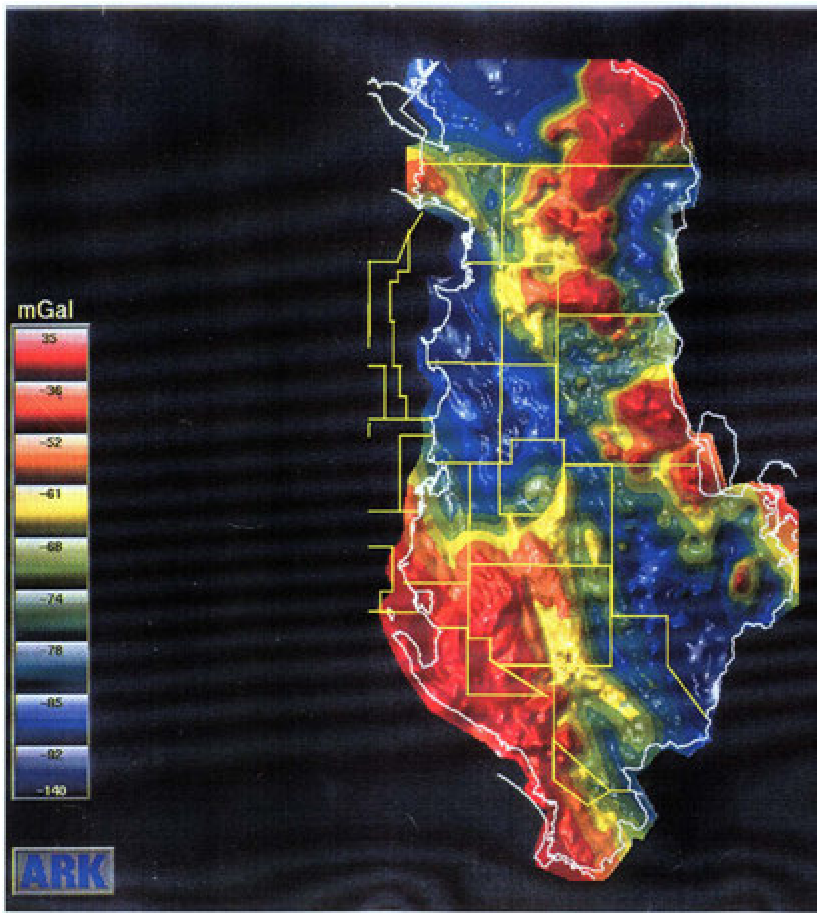
Regional Geophysics (1967 until present)

(L. Lubonja, A. Frasheri, S. Bushati, Nishani P., Silo V.)

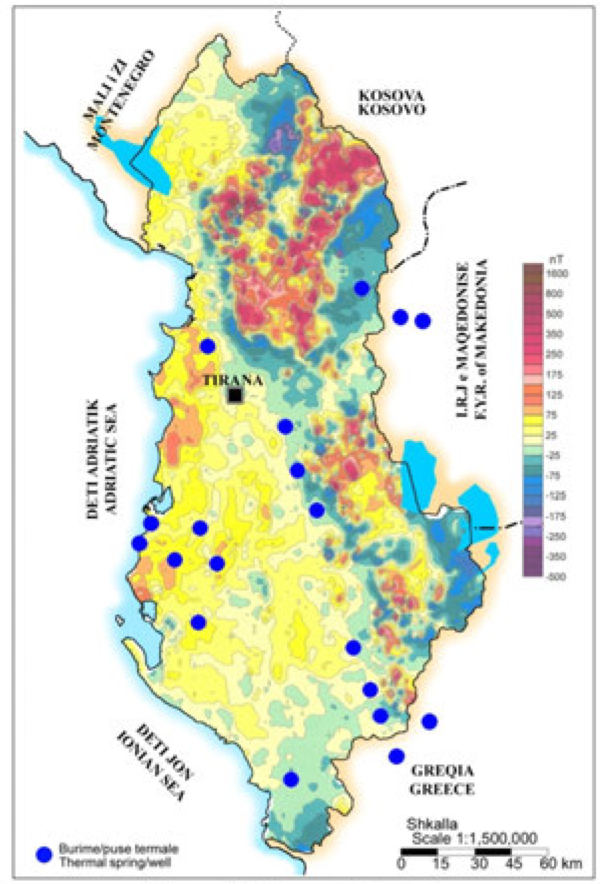


Gravity (1998) and Magnetic (1997-) Maps of Albania, at scale 1:200.000,
Performed by Geophysical Center, Geological Survey of Albania.
Scientific Leader: Academic, Professor, Dr. Salvatore Bushati.

GRAVITY MAP
Bouguer Anomaly



MAGNETIC MAP
(T)



Harta e fushës magnetike totale
Total Magnetic Field Map

Fleta / Plate 3

2

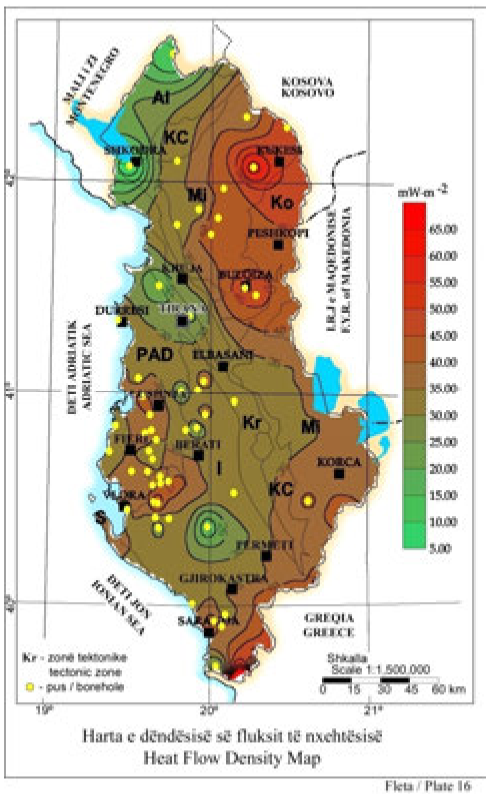
Geothermal studies (Since 1989 **until present**)

Joint project: - Faculty of Geology and Mining

- Insitute of Geophysics, Academy of Sciences, Czech Republic, Prague.

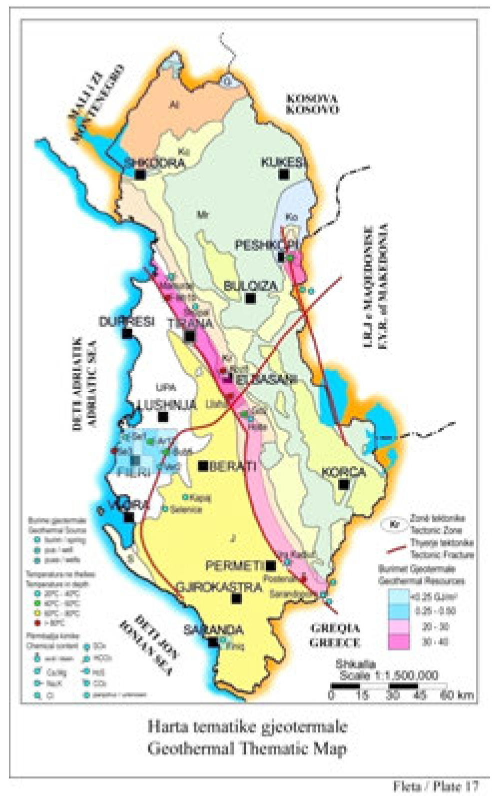
(Frasheri A., Cermac V., Lico R., Bushati S., et al.)

- Temperature Map of Albania at 100; 500; 1000; 2000; 3000 m depth.
- Geothermal Gradient Map of Albania.
- Heat Flow Density Map of Albania.
- Geothermal Resources Map of Albania.



Harta e dëndësisë së fluksit të nxehtësisë
Heat Flow Density Map

Fleta / Plate 16



Harta tematike gjeotermale
Geothermal Thematic Map

Fleta / Plate 17

Paleomagnetic Studies

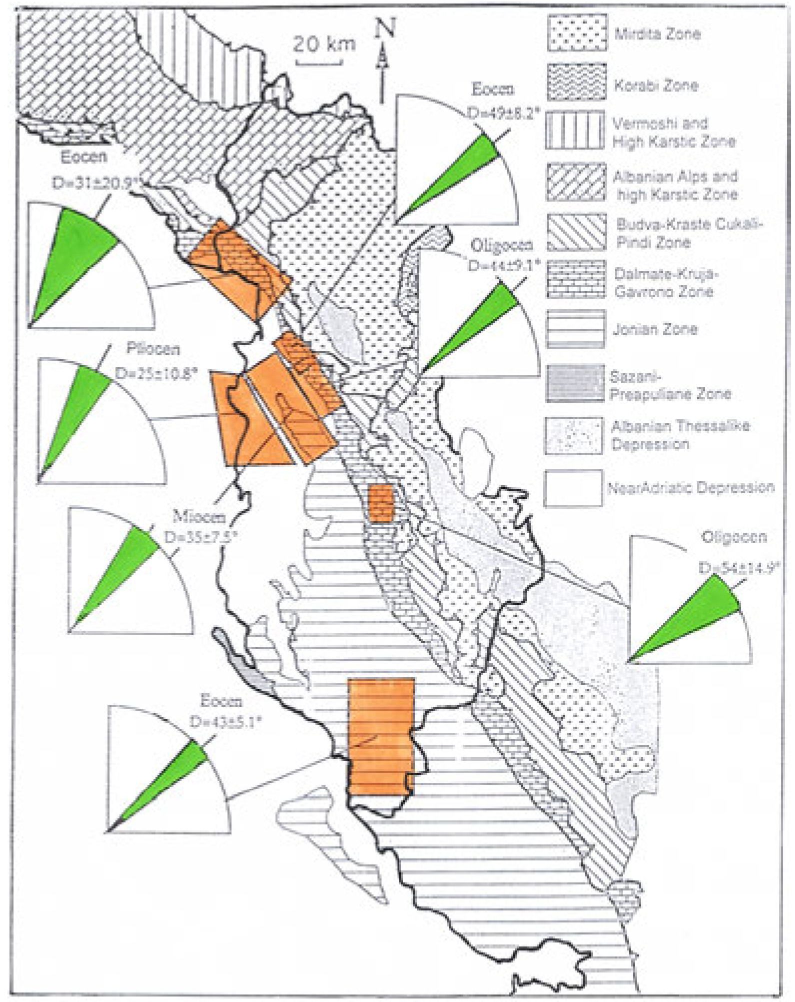
Joint Projects (1989-1997):

- University of Leoben, Austria
(Mauritch H.J.)

- Laboratoir de Paleomagnetisme, Gif sur Yvette
Paris, France
(Kissel C., Lai C, Speranza F)

-University of Thesaloniki
(Condopoulou D.)

 - Faculty of Geology & Mining, Tirana
(Bushati S, Frashëri A. , Alikaj P.)



Mining Geophysics

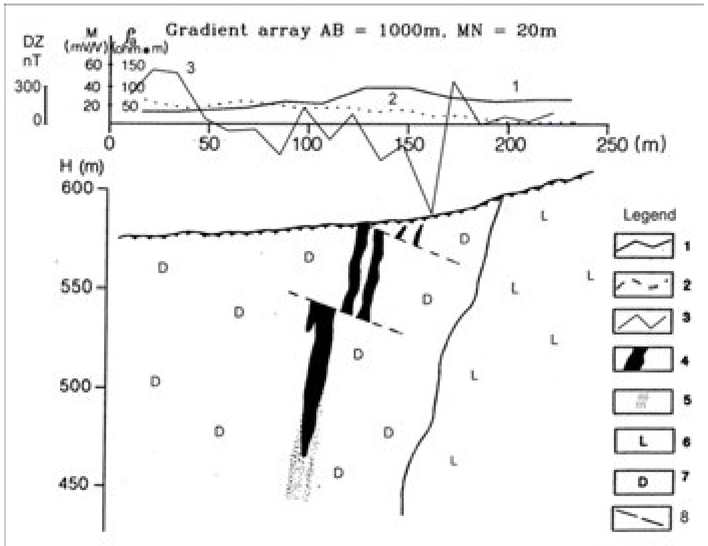
(Lubonja L., Frashëri A., Avxhiu R., Alikaj P., Bushati S.)

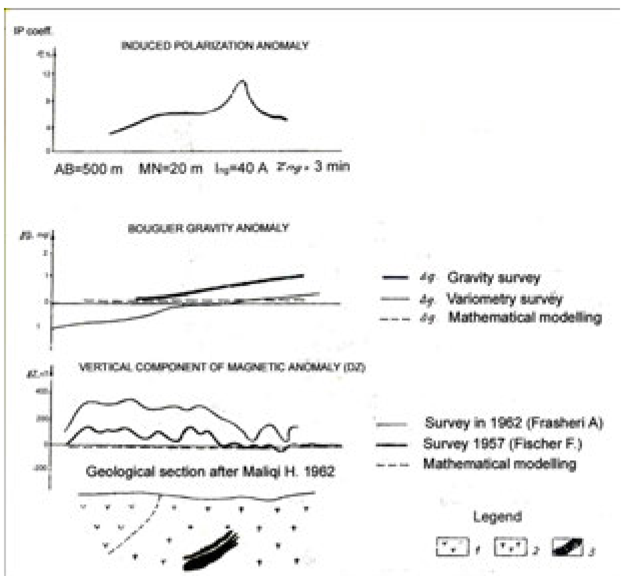
1. Experimentation and application in Albania of new geophysical methods for the exploration of copper and chrome ores:

- Induced Polarization (1962-),
- Magnetic micro-survey (1967-),
- IP and RD Real Section (1978-),
- Depth Investigation Increasing of Mining Geophysics (1984-).
- Physical and Mathematical Modeling, inversion(1973-)

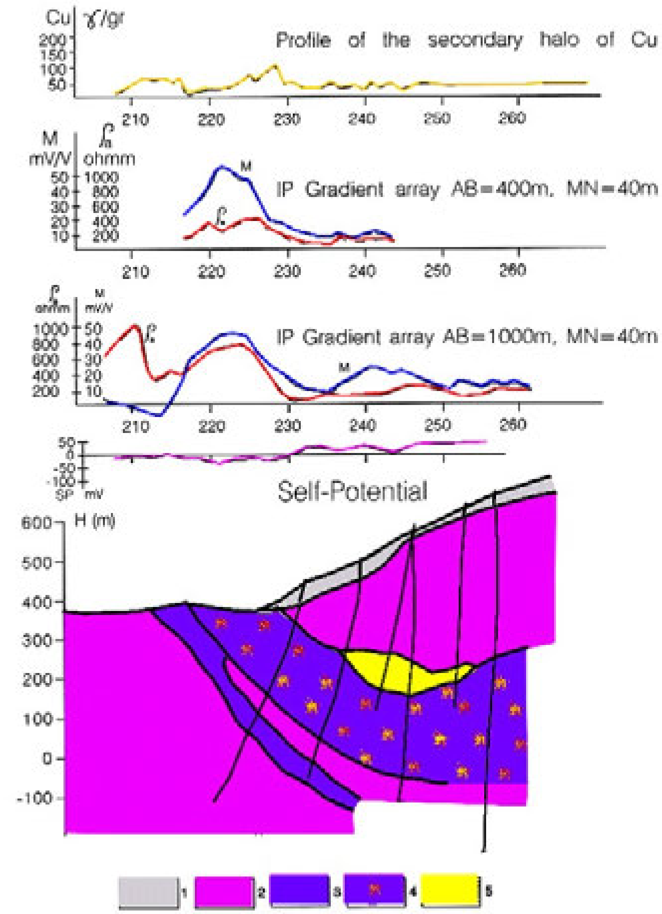
2. Extension of the application field of the geophysical methods in the search for:

- chrome,
- copper,
- asbestos,
- bauxite,
- placer of heavy, rare and precious minerals,
- Geotechnical and environmental engineering investigation,
- Hydrogeological exploration,
- Application of Self-potential method for direct exploration of oil and gas reservoirs





Geophysical Exploration of chromites

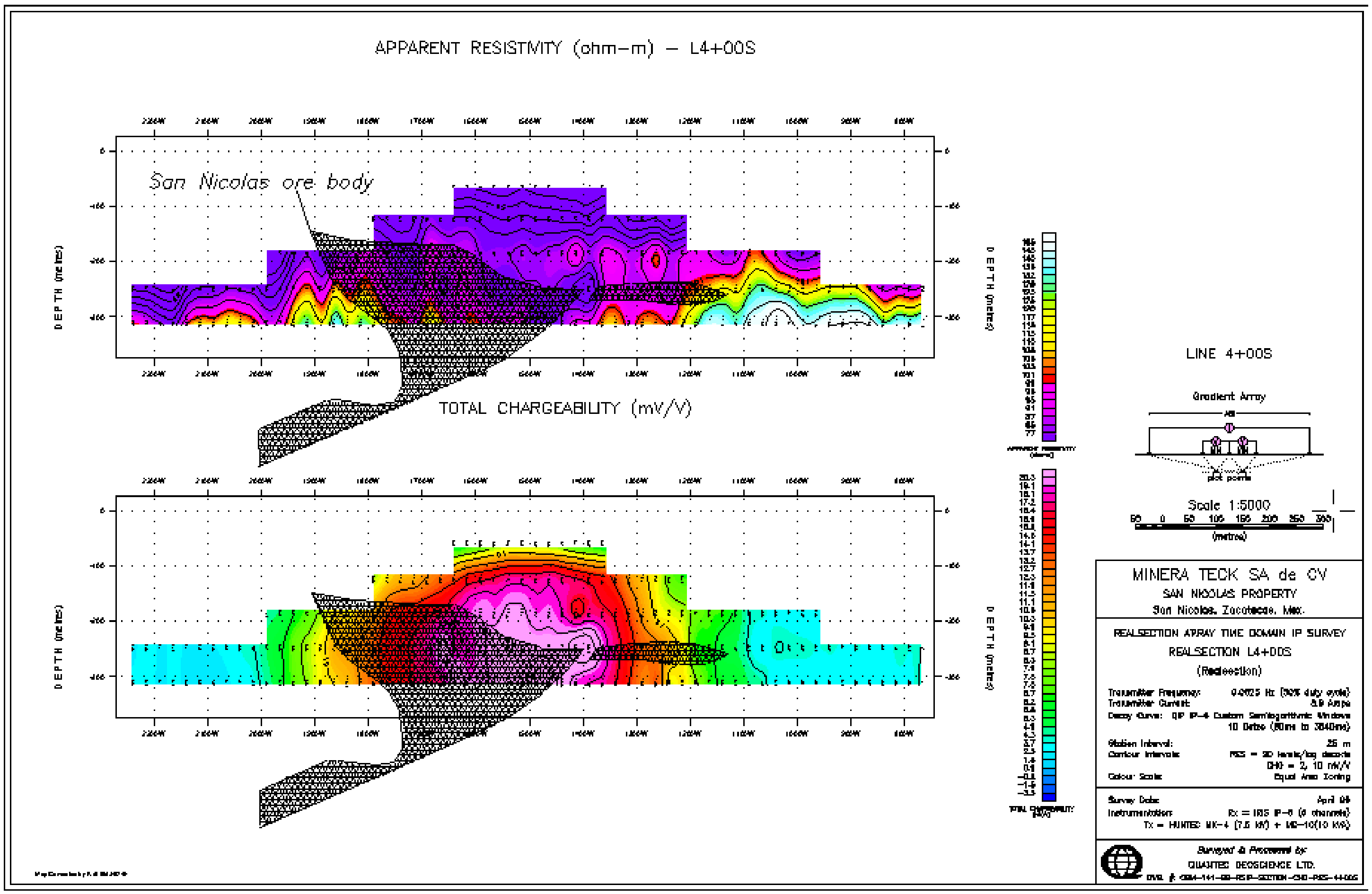


Geophysical Exploration of copper

IP Real Section: New survey and interpretation geoelectrical method (1978-)

(Alikaj P.)

Historic case:
Saint Nicolas, Property, Polymetallic Deposit, Mexico



Oil and Gas Exploration

Integrated geological-geophysical Oil and Gas Exploration and deep wells design

(Nishani P., Lubonja L., Frashëri A.) (1964-), Silo V. (1973-).

Well logging studies, overpressures studies (R. Liço) (1964-)

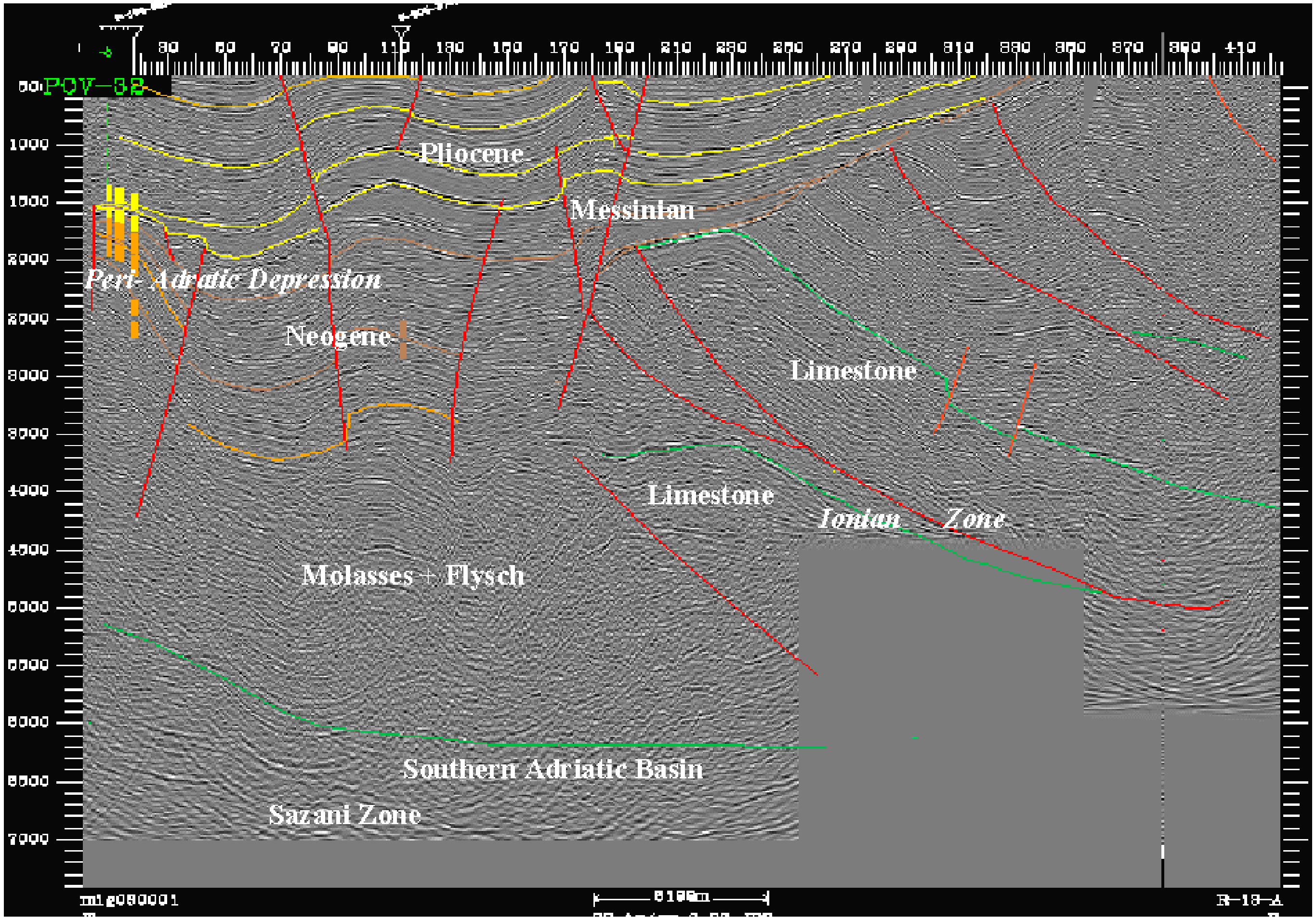
Ardenica-Kolonja

Seismic Line

(Nishani P., coauthor

of the well design)

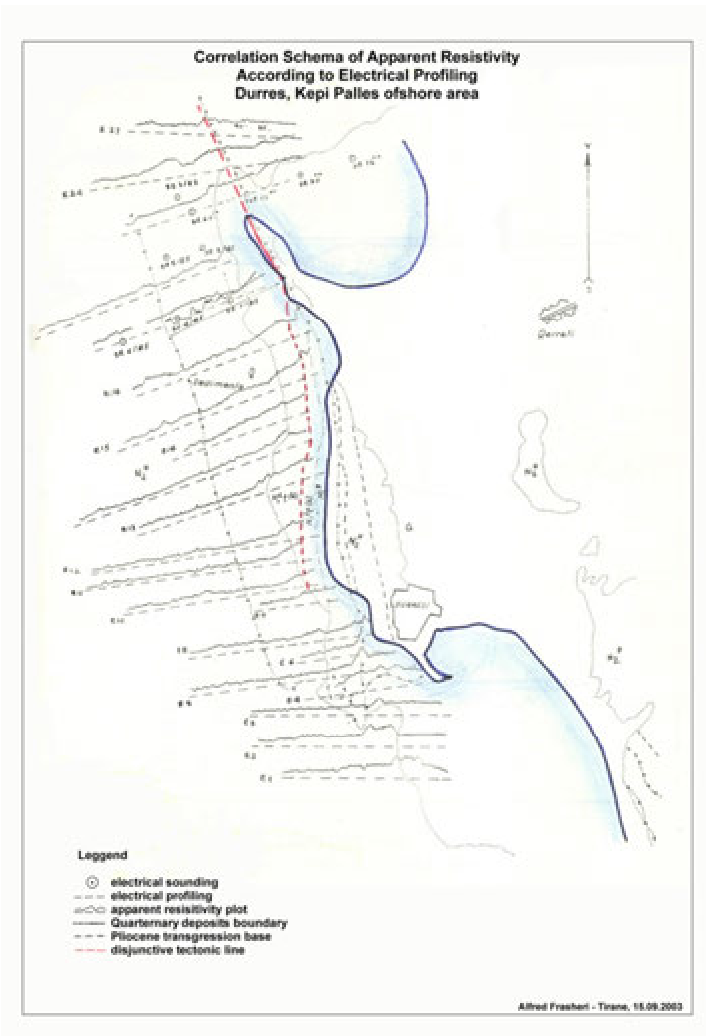
(After ALBPETROL)

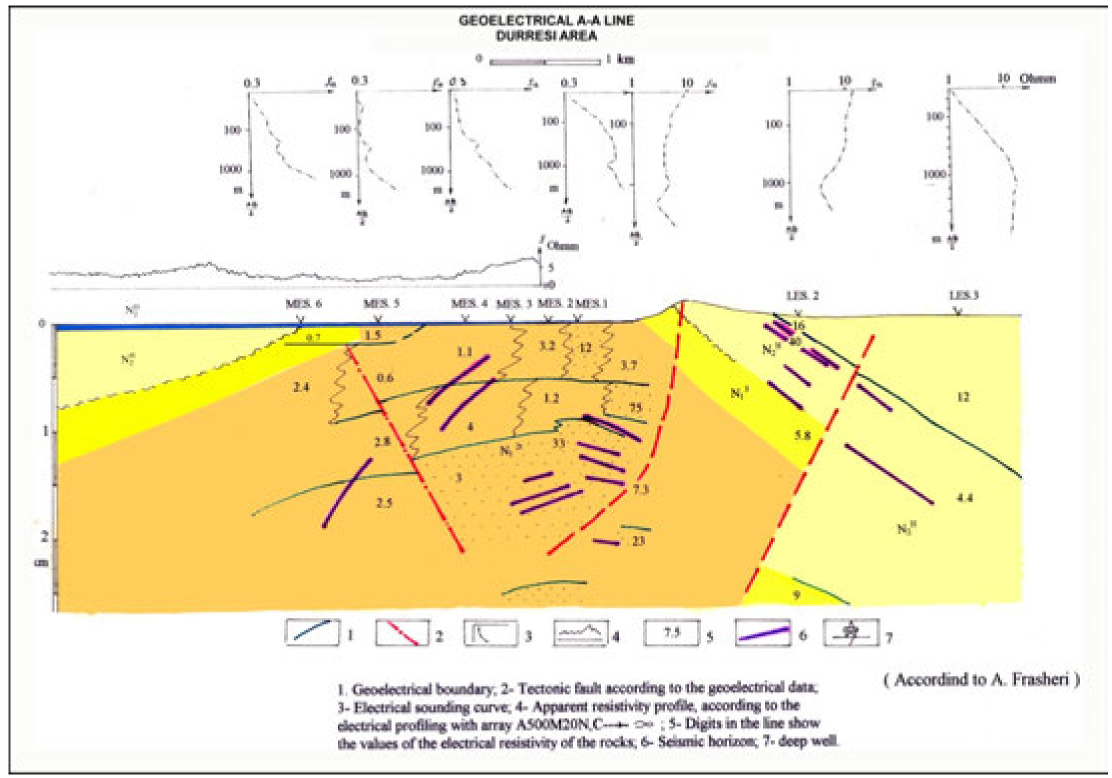


Marine Geoelectrical surveys in Albanian Adriatic Shelf

(Frashëri A.) (1975-1991).

Durresi-Palla Cape Adriatic Shelf area





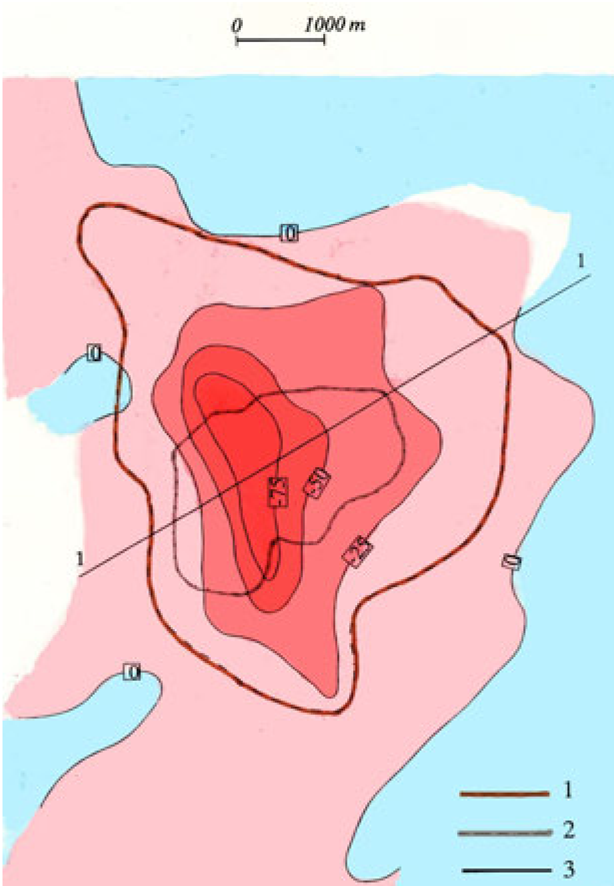
Direct Oil Exploration

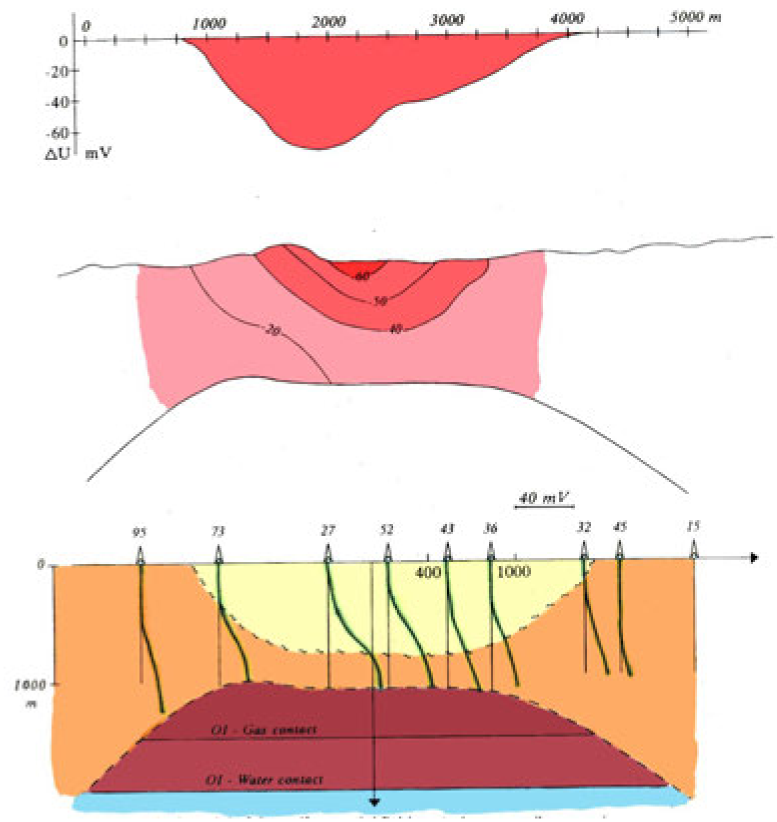
(Frashëri A., Liço R.) (1975-1986).

Self Potential Field Map

Self Potential Profile

Ballshi Oil and Gas Reservuar



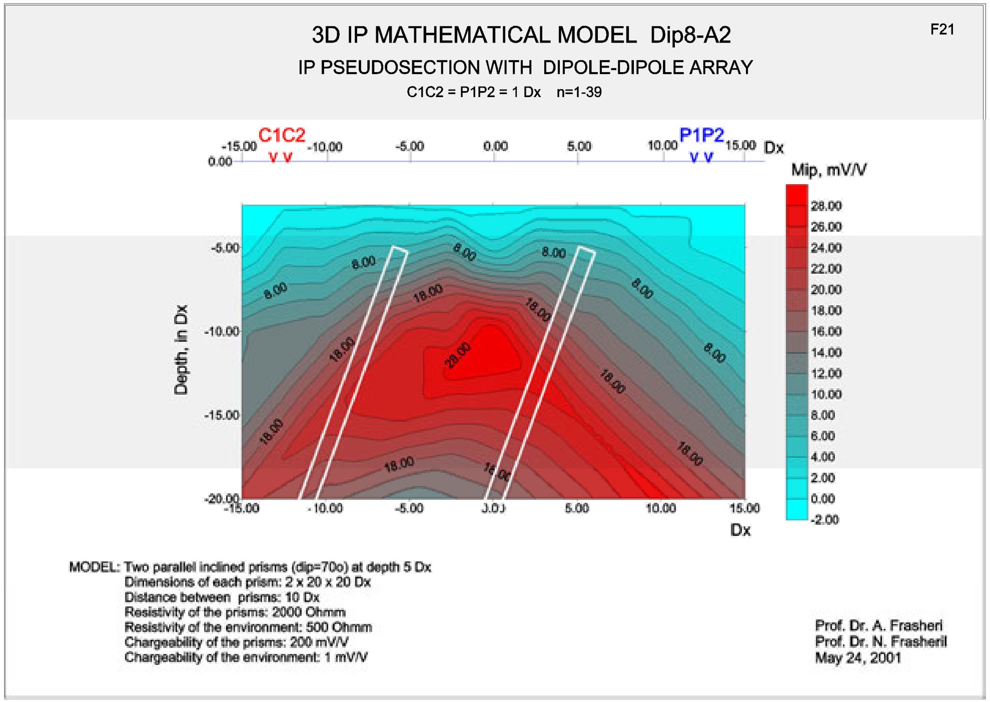


Physical & Mathematical Modeling

- Application of mathematical methods in data processing and interpretation of geophysical information (Gravity, Magnetic, Electric), with the aid of computers, compilation of algorithms and programs for these purpose. (Since 1972) (Lubonja L., Frashëri A., Bushati S., Alikaj P., Beqiraj G., Frashëri N.)

Last studies:

- Dipole – dipole and pole-dipole survey configurations in the framework of the theorem of reciprocity.
- Some considerations on IP data inversion.

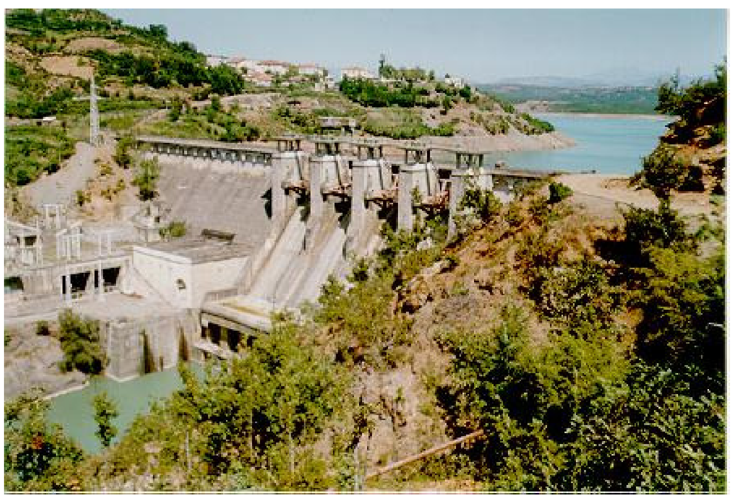


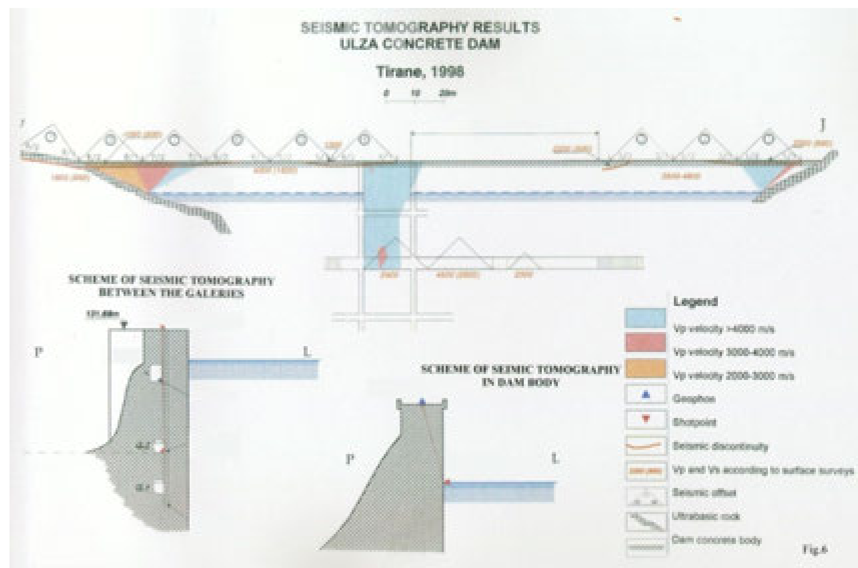
Engineering and Environmental Geophysics

(Since 1982),(Frashëri A., Nishani P., Alikaj P., Silo V.)

- Seismic and geoelectric tomography for in-situ:
- Dam's investigation.
- Slope stability and landslide investigation.
- Environmental impact assessment.
- Ground and rocks investigation in the dam area.
- Karstic zones investigation.
- Soil and rocks investigation in the construction area, highways, tunnels etc.
- Evaluation of the quality of the concrete during the construction of the works, in the airports runways etc.
- Landfill investigation

ULZA HYDROPOWER DAM SEISMIC TOMOGRAPHY





VAU DEJES HYDROPOWER DAM
(Raw Material)

GEOELECTRIC AND SEISMIC TOMOGRAPHY

PRERJE REALE E REZISTENCES ELEKTRIKE SPECIFIKE TE DUKSHME
DHE E SHPEJTESIVE Vp dhe Vs E VALEVE TE DIFRAGUARA
HIDROCENTRALI I VAUT TE DEJES
DIGA ME MATERIAL VENDI
Tirane, 1998

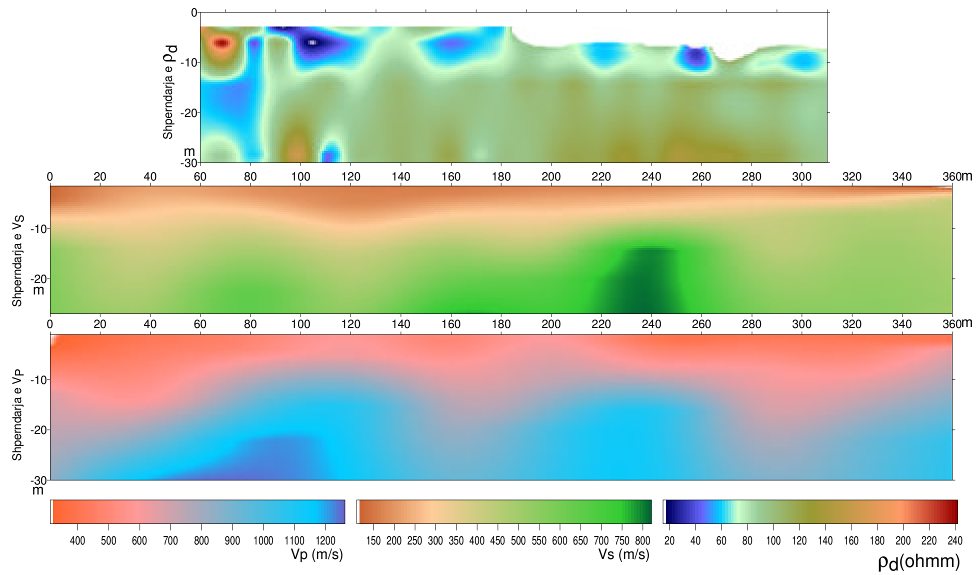
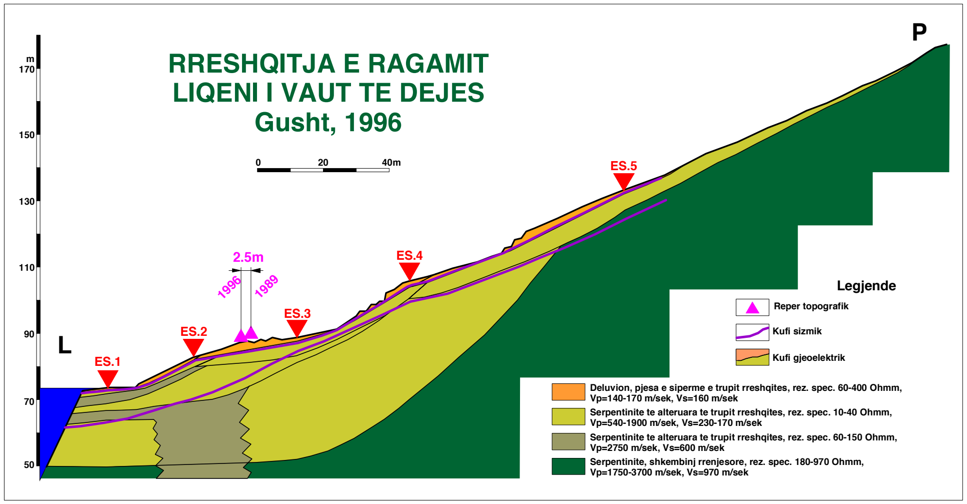


Fig. 12-a

Landslide Investigation

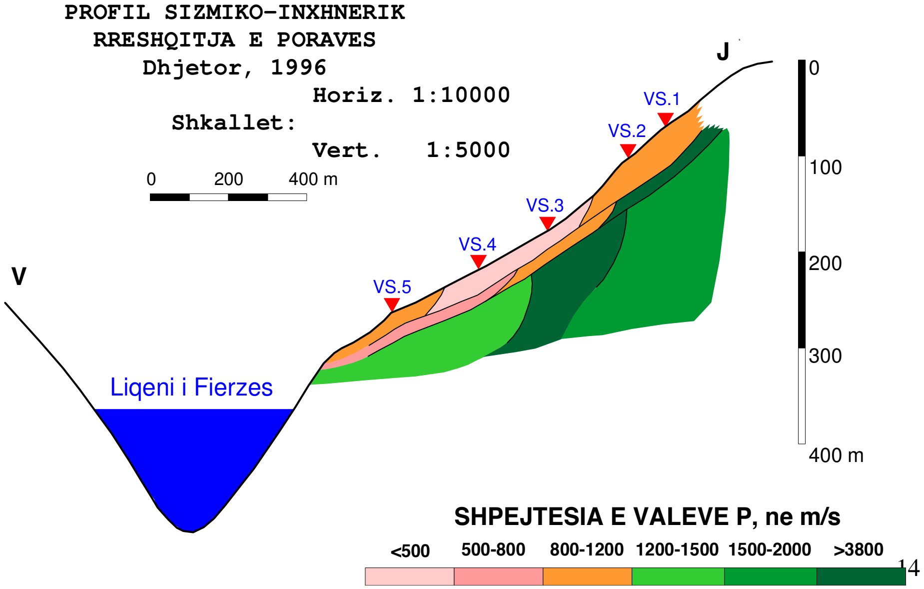
RAGAMI LANDSLIDE: VAU DEJES LAKESHORE

GEOPHYSICAL ENGINEERING PROFILE



PORAVA LANDSLIDE: FIERZA LAKESHORE

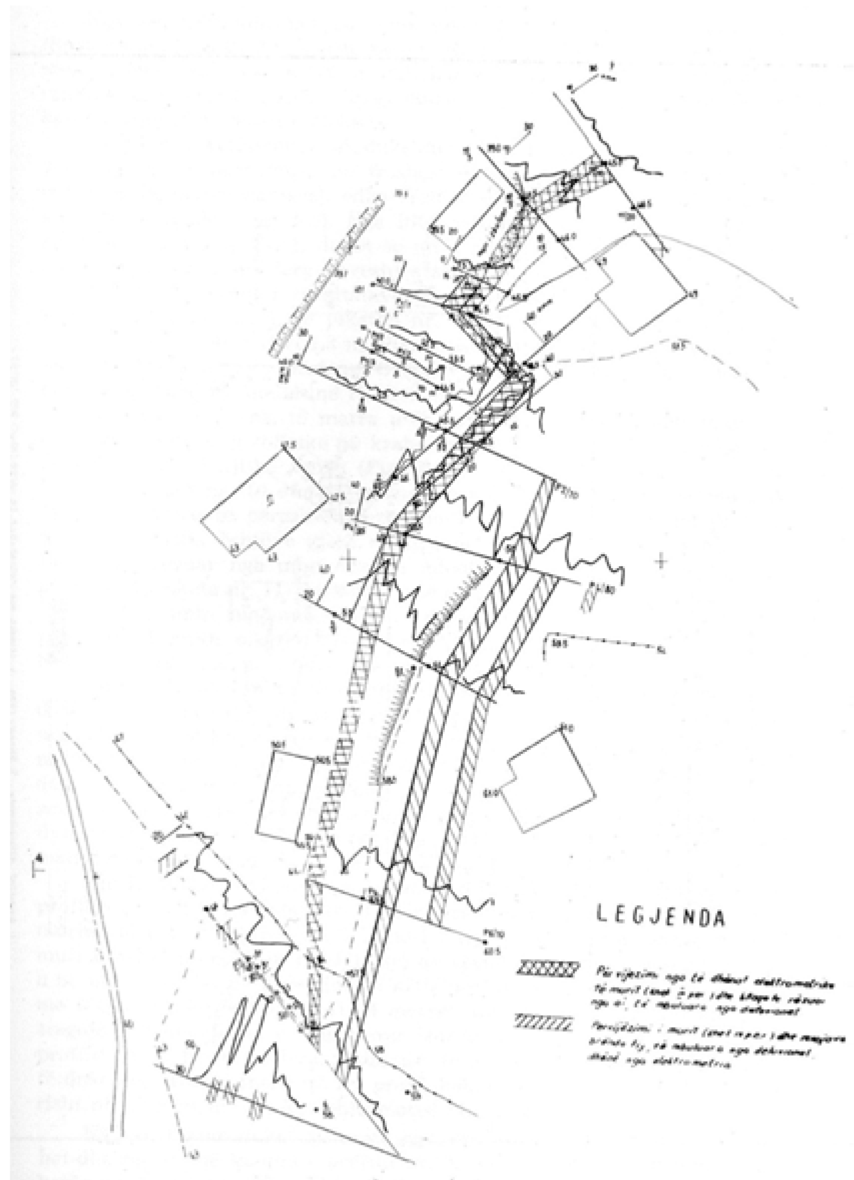
SEISMIC ENGINEERING PROFILE



Archaeological Geophysical Research

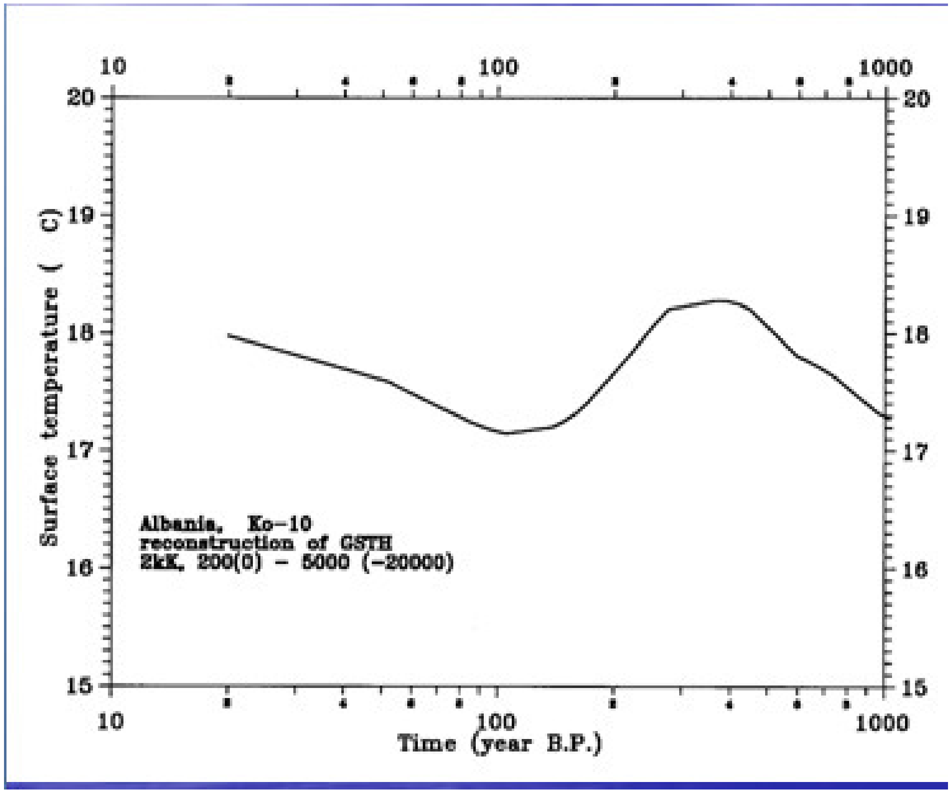
(Frashëri A., Avxhiu R.) (1975-)

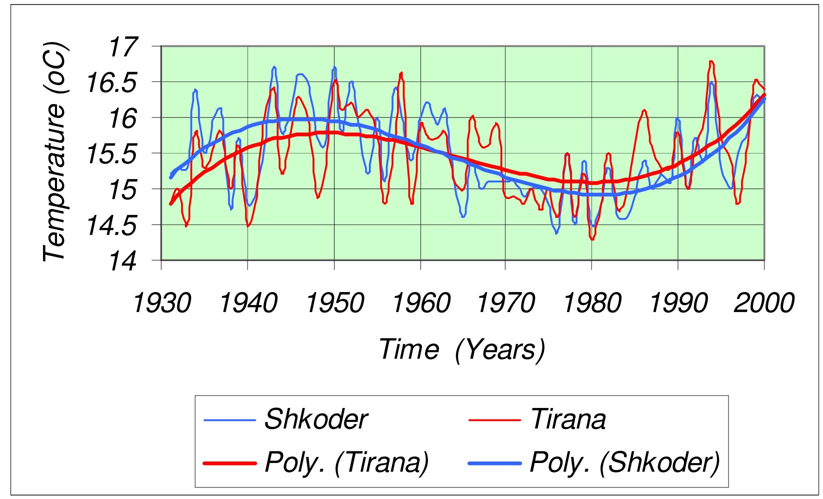
MARGLLICI CASTEL, PATOS



Paleoclimate change (2002-until today)

(Frashëri A.)





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Thank you very much for your attention!

WORLD **GEOTHERMAL CONGRESS 2010.**
Bali, Indonesia, 25-29 April 2010.

GEOTHERMAL ENERGY RESOURCES IN ALBANIA-COUNTRY UPDATE PAPER

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Keywords: Geothermal energy, direct use, heat flow,.

ABSTRACT

Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters are sulfate, sulfide, methane, and iodinate-bromide types. Thermal sources are located in three geothermal zones:

Kruja geothermal zone represents a zone with bigness geothermal resources, in carbonate reservoirs.
Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs.
Peshkopia gjeotermal zone at northeastern area of Albania. Several springs are located with disjunctive tectonics of the gypsum diapir.

The geothermal situation in Albania offers three directions for the exploitation of geothermal energy:

Firstly, the use of the ground heat flow for space heating and cooling, by borehole heat exchanger-heat pumps systems.
Secondly, thermal sources of low enthalpy are natural sources or wells in a wide territory of Albania. They represent the basis for a successful use of modern technologies for a <u>*complex and cascade exploitation*</u> of this energy:

1. SPA clinics for treatment of different diseases and hotels for eco-tourism.
2. The hot water for heating and sanitary waters of the SPA and hotels, greenhouses and aquaculture installations.
3. From thermal waters it is possible to extract chemical microelements.

Thirdly, the use of deep abandoned oil and gas wells as “Vertical Earth Heat Probe”.

Actually in Albania has been published “Atlas of Geothermal Resources in Albania (2004) (Frashëri A. et. Al. 2004). Geothermal team from Faculty of Geology and Mining and Department of Energy of Faculty of Mechanical Engineering, during 2008 has worked for the Project: “Platform for integrated and cascade use of geothermal energy of low enthalpy in the framework of energetic balance of Albania”, in the framework of the National Program for Research and Development, “Water and Energy” 2007-2009 (Frashëri A. et. Al. 2008). Have been published a monograph: “Space Heating/Cooling Borehole-Vertical Heat Exchanger-Heat Pump System” (Frashëri A. et. Al. 2008). In same time, we have prepared first part of three project ideas: “Geothermal Center for integrated and cascade direct use of geothermal energy of Kozani-8 well, near Elbasani City” (spa-hotel with hot pools, greenhouse and aquacultyre instalations (spirulina and fisch) (Frashëri A. et. Al. 2008), Project idea for space heating of Korça University using borehole-vertical heat exchanger-heat pump system (Frashëri A. et. Al. 2008), and project idea for set up of the “Geo-Energy Ressouces Laboratory” in the Department of Energy Reasources, Faculty of Geology and Mining. The Promemory “Earth Heat is an alternative, environ friendly renewable energy, which is necessary to use in Albania” has been addressed to the Albanian Government.

Periodically, results of the geothermal energy studies in Albania have been published and presented in International Symposiums, Conferences and Workshops.

1. INTRODUCTION

Paper represents a summary of the important results of the Monograph "Atlas of geothermal resources in Albania" 2004 The Monograph is prepared in the framework of the National Program for Research and Developing- Natural Resources, 2003-2005. This Atlas represents the publication of the results of studies which were performed in the framework of the Committee for Sciences and Technology of Albania Projects and agreement between the Faculty of Geology and Mining, and the Geophysical Institute, Czech Acad. Sci., Prague, European Commision-International Heat Flow Commission and UNDP-GEF/SGP Tirana Office projects [Frasheri A. 1992, Frasheri A. et al. 1994, 1995, 1996, 2001, 2003].

In Albania there are many thermal water springs and wells of low enthalpy, with a temperature of up to 65.5°C, which indicates that there are possibilities for direct use of the geothermal energy. In Albania the new technologies of direct use of geothermal energy are either partly developed or remain still untouched. Integrated and cascade use of geothermal energy of low enthalpy will be represent an important direction for profitable investment. Exploitation of geothermal energy will have a direct impact in the development of the regions, by increasing their per capita income and at the same time ameliorating the standard of living of the people.

2. GEOLOGY BEACKGROUND

The Albanides represent the main geological structures that lie on the territory of Albania. They are located between the Dinarides in the north and the Helenides in the south, and together they form the Dinaric Branch of Mediterranean Alpine Belt. Albanides are divided in two big peleogeographical zones: the Inner Albanides and the External Albanides. Korabi, Mirdita (ophiolitic belt), presents the Inner Albanides and Gashi zones. The Alps, the Krasta-Cukali, the Kruja, the Ionian zone, the Sazani zone and the Pre-Adriatic Depression present the External Albanides. Depression as a part of Albanian Sedimentary Basin, continued towards the shelf of the Adriatic Sea. The geological cross-section of Albanian Sedimentary Basin is about 15 km thick and it continues also in the Adriatic Sea Shelf.

Ionian zone is developed as a large pelagic trough in the Upper Triassic. There, the evaporites of the Permian-Triassic are overlapped by a thick carbonatic formation of the Upper Triassic-Eocene. The geological section on this carbonatic formation is covered by Oligocene flysch, a flyschoid formation of the Aquitanian and by schilieres of the Burdigalian, Helvetian and particularly of Serravalian-Tortonian molasse. Burdigalian deposits are overlapped transgressively with an angular unconformity, anticline belts. The Tortonian Age deposists have filled the synclinal belts of Ionic and Kruja tectonic zones.

Miocene and Pliocene molasse of Peri-Adriatic Depression overlies the structures of northern part of the Ionian zone. The structure of Neogenic molasses represents the upper tectonic stage of the structure of the Peri-Adriatic Depression.

In the over part of the section of Kruja zone, the carbonatic neritic rocks of the Cretaceous-Paleogene age are overlying the Oligocene flysch of a thickness of 5 km.

The structures of the Albanides are typically Alpine ones. The SSE-NNW directions represent their general strike. The structures are asymmetrical and have a western vengeance. Recumbent, overthrusted and overtwisted structures are found, too. Generally, their western flanks are affected by disjunctive tectonic.

3. METHODS AND STUDY AREA

Geothermal studies carried out in Albania are oriented toward the study of the distribution of the geothermal field and the natural thermal water springs and wells. Geothermal studies were extended all over the country territory.

The temperatures have been measured and the geothermal gradient and the heat flow density at different depths have also been calculated (Frasheri et al. 1995). Temperature measurements were carried out both in 145 deep wells, in boreholes and in mines, at different hypsometric levels. The temperature in the wells was recorded at regular intervals. It was measured by means of resistance and thermistor thermometers. The average absolute measurement error was 0.3°C. The measurements were carried out in a steady-state regime of the wells filled with mud or water. The recorded data were processed using the trend analysis of first and second degrees. The chemical composition of the waters was found. The output of the springs and wells and their hydrogeology was evaluated.

4. RESULTS

4.1.Geothermal Regime

The Geothermal Regime of the Albanides is conditioned by tectonics of the region, lithology of geological section, local thermal properties of the rocks and geological location (Frasheri A. 1992, Frasheri et al. 1994, 1995, 2004).

4.1.1. Temperature

The geothermal field is characterized by a relatively low value of temperature. The temperature at 100 meters depth vary from less than 10 to almost 20°C, with lowest values in the mountain regions. The temperature is 105.8°C at 6000 meters depth, in the central part of the Peri-Adriatic Depression. The isotherm runs parallel the Albanides strike (Fig. 1). Going deeper and deeper the zones of highest temperature move from southeast to northwest, towards the center of the Peri-Adriatic Depression and even further towards the northwestern coast. The temperatures in ophiolitic belt are higher than in sedimentary basin, at the same depth.

4.1.2. Geothermal Gradient

In the External Albanides the geothermal gradient is relatively higher. The geothermal gradient displays the highest value of about 21.3 $mK.m^{-1}$ in the Pliocene clay section in the centre of Peri-Adriatic Depression. The largest gradients are detected in the anticline molasses structures of the center of Pre-Adriatic Depression (Fig. 5). The gradient decreases about 10-29% where the core of anticlines in Ionic zone contains limestone. The lowest values of 7-11 $mK.m^{-1}$ of the gradient are observed in the deep synclinal belts of Ionic and Kruja tectonic zones (Fig.2).

In the ophiolitic belt of the Mirdita tectonic zone, the geothermal gradient values increase up to 36 $mK.m^{-1}$ at northeastern and southeastern part of the Albania.

4.1.3. Heat Flow Density:

Regional pattern of heat flow density in Albanian territory is presented in the Heat Flow Map. There are observed two particularities of the scattering of the thermal field in Albanides (Fig. 3):

Firstly, maximal value of the heat flow is equal to 42 mW/m^2 in the center of Peri-Adriatic Depression of External Albanides. The 30 mW^{-2} value isotherm is open towards the Adriatic Sea Shelf. These phenomena have taken place owing to the great thickness of sedimentary crust, mainly carbonatic one in this zone.

Secondly, in the ophiolitic belt at eastern part of Albania, the heat flow density values are up to 60 mW/m^2. The contours of Heat Flow Density give a clear configuration of ophiolitic belt. Radiogene heat generation of the ophiolites is very low. In these conditions, increasing of the heat flow in the ophiolitic belt, is linked with heat flow transmitting from the depth. The granites of the crystalline basement, with the radiogenic heat generation, represent the heat source.

4.2. Geothermal energy resources in Albania

Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters with a temperatures that reach values of up to 65.5°C are sulfate, sulfide, methane, and iodinate-bromide types (Frasheri A. et al. 1996, 2004) (Tab. 1, Fig.4). In many deep oil and gas wells there are thermal water fountain outputs with a temperature that varies from 32 to 65.5°C (table 2, Fig. 3)

Albanian geothermal areas have different geologic and thermo-hydrogeological features. Thermal sources are located in three geothermal zones (fig. 4):

Kruja geothermal zone represents a zone with bigness geothermal resources. Kruja zone has a length of 180 km. Kruja Geothermal Zone is extended from Adriatic Sea at North and continues in South-Easter area of Albania and in Konitza area in Greece. Photo 1 shows Langarica - Permet thermal springs at southern Albania. Identified resources in carbonate reservoirs in Albanian side are 5.9×10^8-5.1×10^9 GJ. The most important resources, explored until now, are located in the Northern half of Kruja Geothermal Area, from Llixha-Elbasan in the South to Ishmi, in the North of Tirana. The values of specific reserves vary between 38.5-39.63 GJ/m^2.

Kruja geothermal area represents an anticline structure chain with carbonatic core of Cretaceous-Eocene age. They are covered with Eocenic- Oligocenic flysch. Anticlinals are linear with as length of 20-30 km. They are assymmetric and their western flanks are separated from disjunctive tectonics. Geothermal aquifer is represented by a karstified neritic carbonatic formation with numerous fissures and microfissures.

In the Ishmi area, Ishmi 1-b well has been drilled in 1994. It is situated in the top part of the limestone structure. It is located 20 km North-West of Tirana, in the plain area, near "Mother Theresa" Tirana airport. It meets limestone at 1300m of depth and goes through a carbonatic coupe of 1016 m thickness.

Kozani 8 well has been drilled in 1989 (Photo 2). It is situated 35 km South- East of Tirana and 8 km North- West of Elbasani. It is situated on hills close to Tirana- Elbasani national road. It meets limestone at 1810m of depth and goes 10m deep in them.

Since the end of the drilling to this day hot water continues to fountain from Ishmi 1-b and Kozani 8 wells.

Elbasani Llixha watering place is about 12 km South of Elbasani. There are seven spring groups that extend like a belt with 320^o azimuth. All of them are connected with a the main regional disjunctive tectonics of Kruja zone. Thermal waters flow out through the contact of conglomerate layer with calcolistolith. In this area too, the reservoir is represented by the Llixha limestone structure. These springs have been known before Second World War.

Surface water temperatures in the Tirana-Elbasani zone vary from 60° to 65.5°. In the aquifer top in the well trunk of Kozani 8 temperature is 80°C. Hot water is mineralized, with a general mineralization of 4.6-19.3 g/l. Elbasani Nosi Llixha water has the following formula:

$$H_2S_{0.403}M_{7.1}\frac{Cl_{59}SO^4_{38}}{Na_{46}Ca_{35}}$$

Peshkopia gjeotermal zone is situated in the Northeast of Albania. Two kilometers East of Peshkopia some thermal springs are situated very close to each other. These thermal springs flow out on Banja river slope. These springs are linked with the disjunctive tectonic seismic-active zone Ohrid Lake-Debar, at periphery of gypsum diapir of Triassic age, that has penetrated Eocenic flysch, which surround it like a ring. The occurrence of thermal waters is connected with the low circulation zone always under water pressure. They are of sulfate-

calcium type, with a mineralization of up to 4.4 g/l, containing 50 mg/l H_2S. Their chemical formula is:

$$H_2S_{0.0495}M_{4.4}\frac{SO^4_{56}}{Ca_{65}}$$

Yield of some of the springs goes up to 14 l/sec. Water temperature is 43.5 °C.

Water temperature and big yield, stability, and also aquifer temperature of Peshkopia Geothermal Area similar are with those of Kruja Geothermal Area. For this reason geothermal resources of Peshkopia Area have been estimated to be similar to those of Tirana-Elbasani area.

Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs.

5. DIRECTIONS FOR THE DIRECT USE OF GEOTHERMAL ENERGY OF LOW ENTHALPY IN ALBANIA

The geothermal situation of low enthalpy in Albania offers three possibilities for the direct use of geothermal waters energy. Geothermal energy exploitation must be realized by integrated scheme of geothermal energy, heat pumps and solar energy, and cascade use of this energy (Frasheri A. 2001, Frasheri A. et al. 2003, 2004).

Firstly, the Ground Heat can be use for space heating and cooling by Borehole Heat Exchanger-Geothermal Heat Pumps modern systems.

Secondly, thermal sources of low enthalpy and of maximal temperature up to 65.5°C.

Thermal waters of springs and wells may be used in several ways:

1. Modern SPA clinics for treatment of different diseases and hotels, with thermal pools, for development of eco-tourism. Such centers may attract a lot of clients not only from Albania, because the good curative properties of waters and springs are situated at nice places, near seaside, Gjinari mountain or Ohrid Lake pearl.

The oldest and important is Elbasani Llixha SPA is located in Central Albania. By national road communication, Llixha area is connected with Elbasani. These thermal springs from about 2000 years ago are known, near of the old road “Via Egnatia" that has passed from Durresi-Ohrid- to Constantinople. All seven groups of the springs in Llixha Elbasani and Kozani-8 well, near of Saint Vladimir Monastery at Elbasani, have the possibilities for modern complex exploitation. Ishmi 1/b geothermal well is located in beautiful Tirana field, near of Mother Theresa- Tirana Airport, near of the Adriatic coastline and Kruja - Skenderbeg Mountain.

Peshkopia SPA was constructed by modern concepts as balneological geothermal center. There are thermal pools, for medical treatment and recreation. Construction of the Peshkopia SPA must be en good example for new SPA construction in Albania.

2. The hot water can be used also for heating of hotels, SPA and tourist centers, as well as for the preparation of sanitary hot water used there. Near these medical and tourist centers it is possible to built the greenhouses for flowers and vegetables, and aquaculture installations.

3. From thermal mineral waters it is possible to extract very useful chemical microelements as iodine, bromine, chlorine etc. and other natural salts, so necessary for preparation of pomades for the treatment of many skin diseases as well as for beauty treatments. From these waters it is possible to extract sulphidric and carbonic gas.

Thirdly, the use of deep doublet abandoned oil and gas wells and single wells for geothermal energy, in the form of a “Vertical Earth Heat Probe”. The geothermal gradient of the Albanian Sedimentary Basin has average values of about 18.7 $mK \cdot m^{-1}$. At 2 000 m depth the temperature reaches a value of about 48°C. In these single abandoned wells a closed circuit water system

can be installed. Near of these wells, can be build greenhouses.

Consequently, the sources of low enthalpy geothermal energy in Albania, which are at the same time the sources of multi-element mineral waters, they represent the basis for a successful use of modern technologies for a *complex and cascade exploitation* of this environmental friendly renewable energy, achieving a economical effectiveness. Such developments are useful also for the creation of new working places and improvement of the level of life for local communities near thermal sources.

6. CONCLUSIONS

1. Albania has geothermal energy resources, which can be direct use as alternative, environmental friendly energy.

2. Resources of the geothermal energy in Albania are;
   a) Natural springs and deep wells with thermal water, of a temperature up to 65.5°C.
   b) Heat of subsurface ground, with an average temperature of 16.4°C and depth Earth Heat Flow.

3. Construction of the space-heating system, based on direct use of ground heat, by using of the shallow borehole heat exchanger (BHE)-Heat Pumps systems, is actually most important direction of the use of geothermal energy.

7. ACKNOWLEDGMENTS

The authors express their thanks also to their colleagues of the Geothermal Team at the Faculty of Geology and Mining of the Polytechnic University of Tirana and of Geophysical Institute at Academy of Sciences of the Czech Republic in Prague, for their scientific collaboration and help in our studies of geothermal energy.

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THERMAL WATER SPRINGS IN ALBANIA

Tab. 1

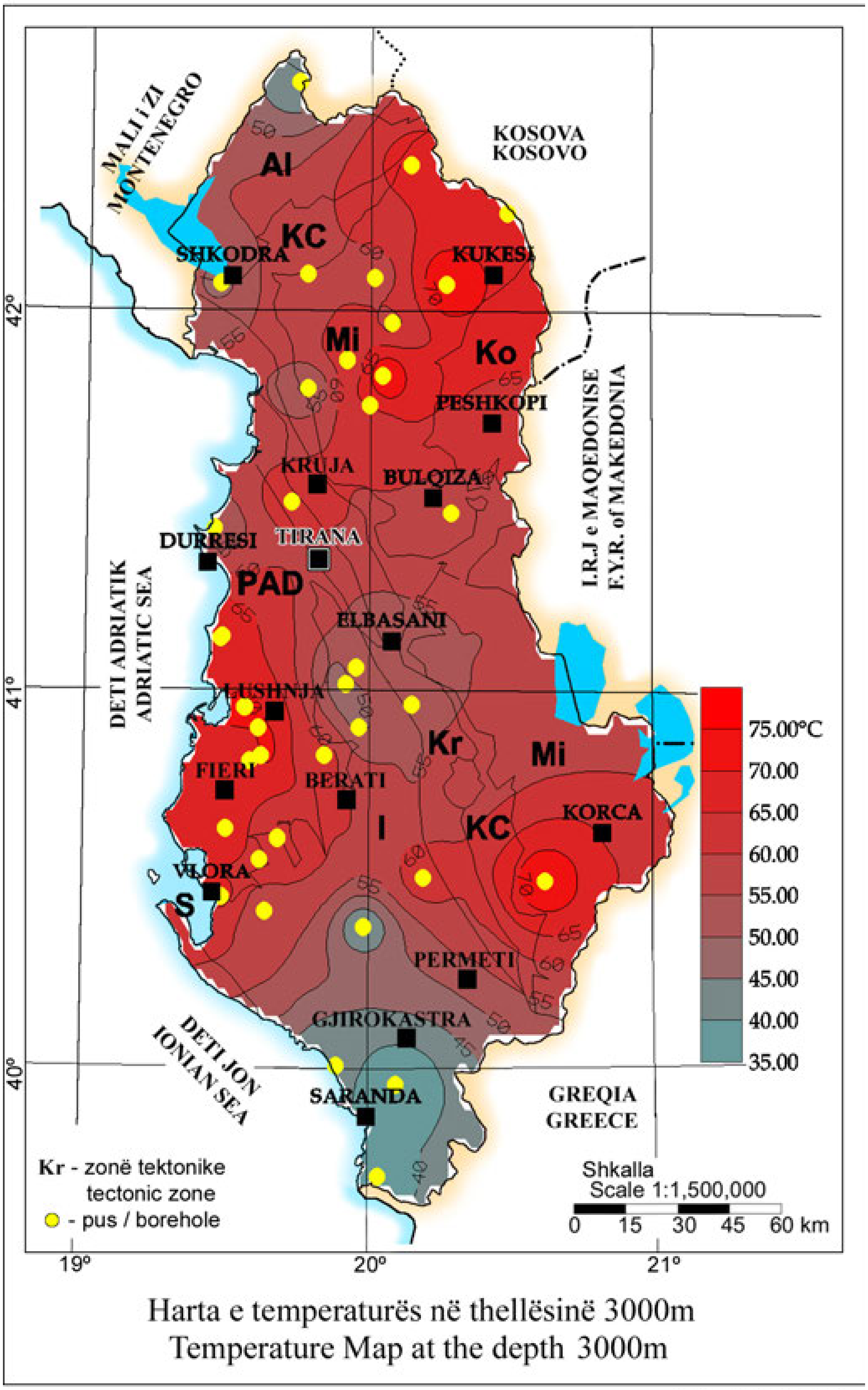
N° of Springs	Location	Temperature in °C	Salt in mg/l	Artesian Spring yield in l.s-1
1	Llixha Elbasan	60	0.3	0
2	Peshkopi	5-43	9	10
3	Krane-Sarande	34		<10
4	Langarica-Permet	6-31		>10
5	Shupal-Tirana	29.5		10
6	Sarandoporo-Leskovik	26.7		>10
7	Tervoll-Gramsh	24		>10
8	Mamurras-Tirane	21	26	>10
9	Steam Postenani springs			

THE OIL AND GAS WELLS THAT HAVE
SELF-DISCHARGE OF THE THERMAL WATER,
Table 2

N°	Well Name	Temperature in °C	Salt in $mg.l^{-1}$	Self-discharge in $l.sec^{-1}$
1	Kozani	65.5	4.6	10.4
2	Ishmi	64	19.3	4.4
3	Galigati	45-50	5.7	0.9
4	Bubullima	48-50	35	
5	Ardenica	38		15-18
6	Ardenica	32		
7	Semani	35		5
8	Verbasi	29.3		1-3

Photo 1. Langarica-Permeti thermal water springs

Photo 2. Geothermak deep well Kozani - 8


MALI i ZI
MONTENEGRO
KOSOVA
KOSOVO
Al
KC
SHKODRA
KUKESI
Mi
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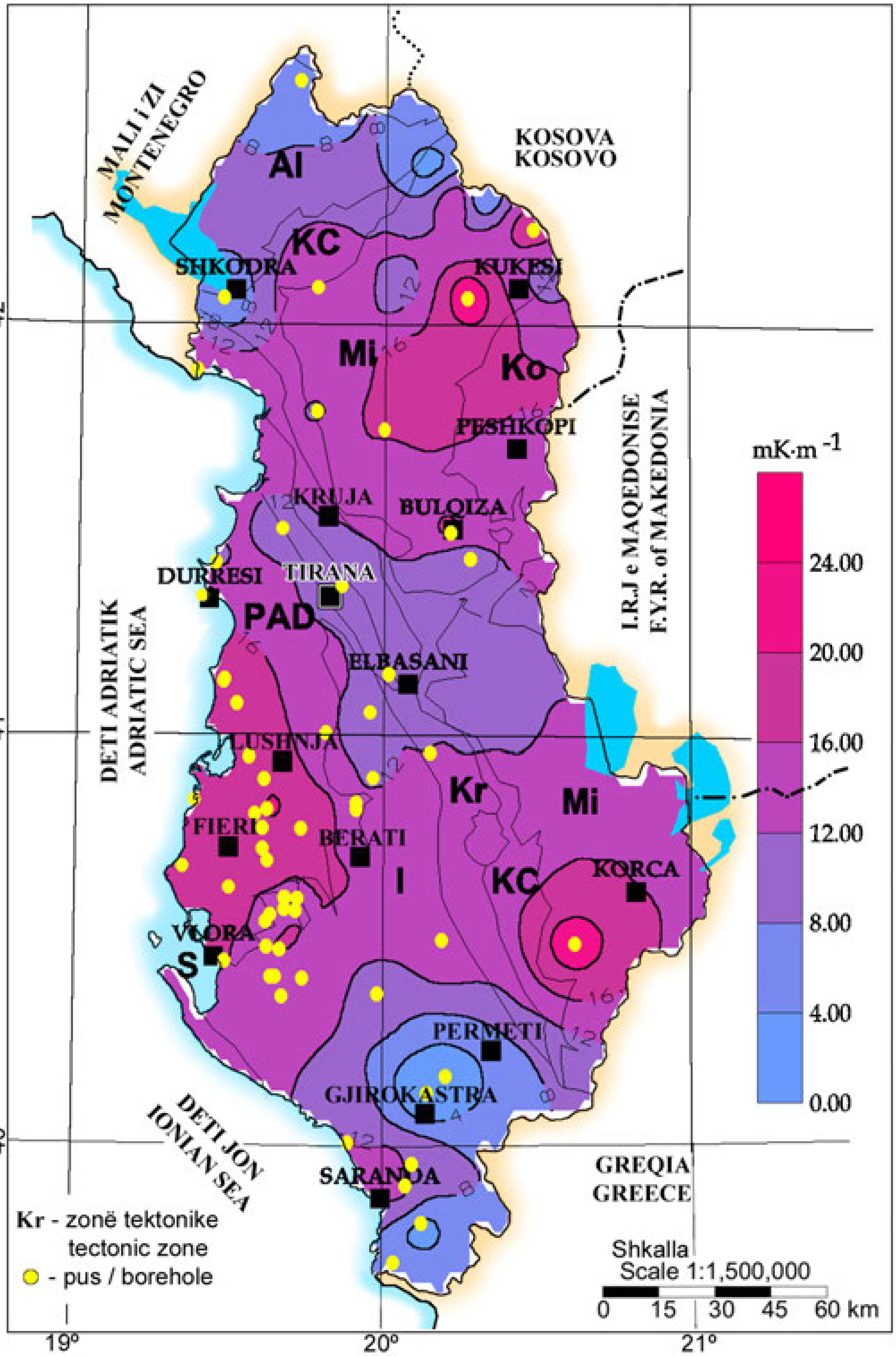
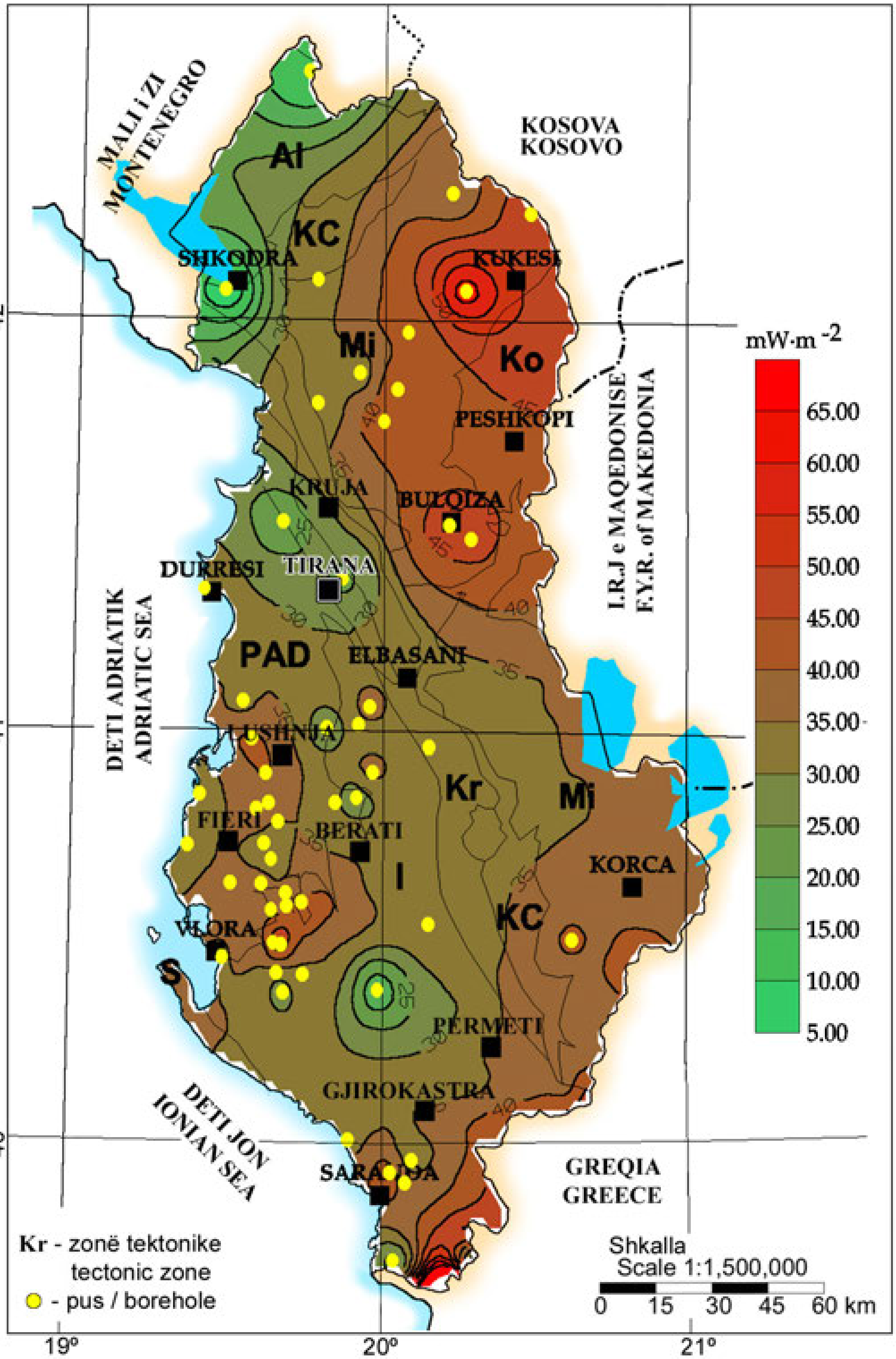
PESHKOPI
I.R.J e MAQEDONISE
F.Y.R. of MAKEDONIA
KRUJA
BULQIZA
DURRESI
TIRANA
PAD
DETI ADRIATIK
ADRIATIC SEA
ELBASANI
LUSHNJA
Kr
Mi
FIERI
BERATI
I
KC
KORCA
VLORA
S
PERMETI
GJIROKASTRA
DETI JON
IONIAN SEA
SARANDA
GREQIA
GREECE
75.00°C
70.00
65.00
60.00
55.00
50.00
45.00
40.00
35.00
42°
41°
40°
19°
20°
21°
Kr - zonë tektonike
tectonic zone
- pus / borehole
Shkalla
Scale 1:1,500,000
0 15 30 45 60 km
Harta e temperaturës në thellësinë 3000m
Temperature Map at the depth 3000m

Fig. 1



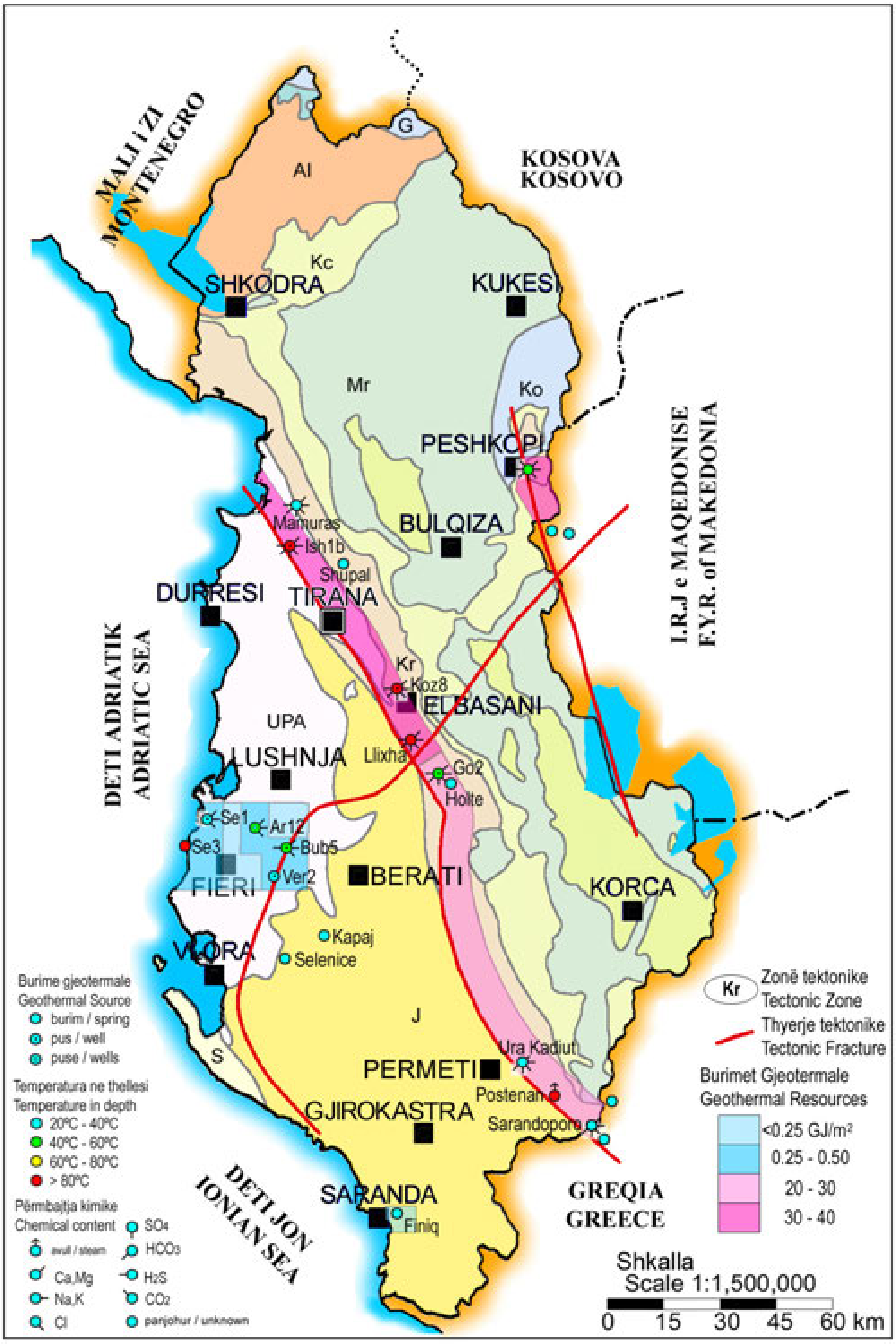
Harta e gradientit gjeotermal mesatar
Average Geothermal Gradient Map

Fig. 2



Harta e dëndësisë së fluksit të nxehtësisë
Heat Flow Density Map

Fig. 3



Harta tematike gjeotermale
Geothermal Thematic Map

Fig. 4

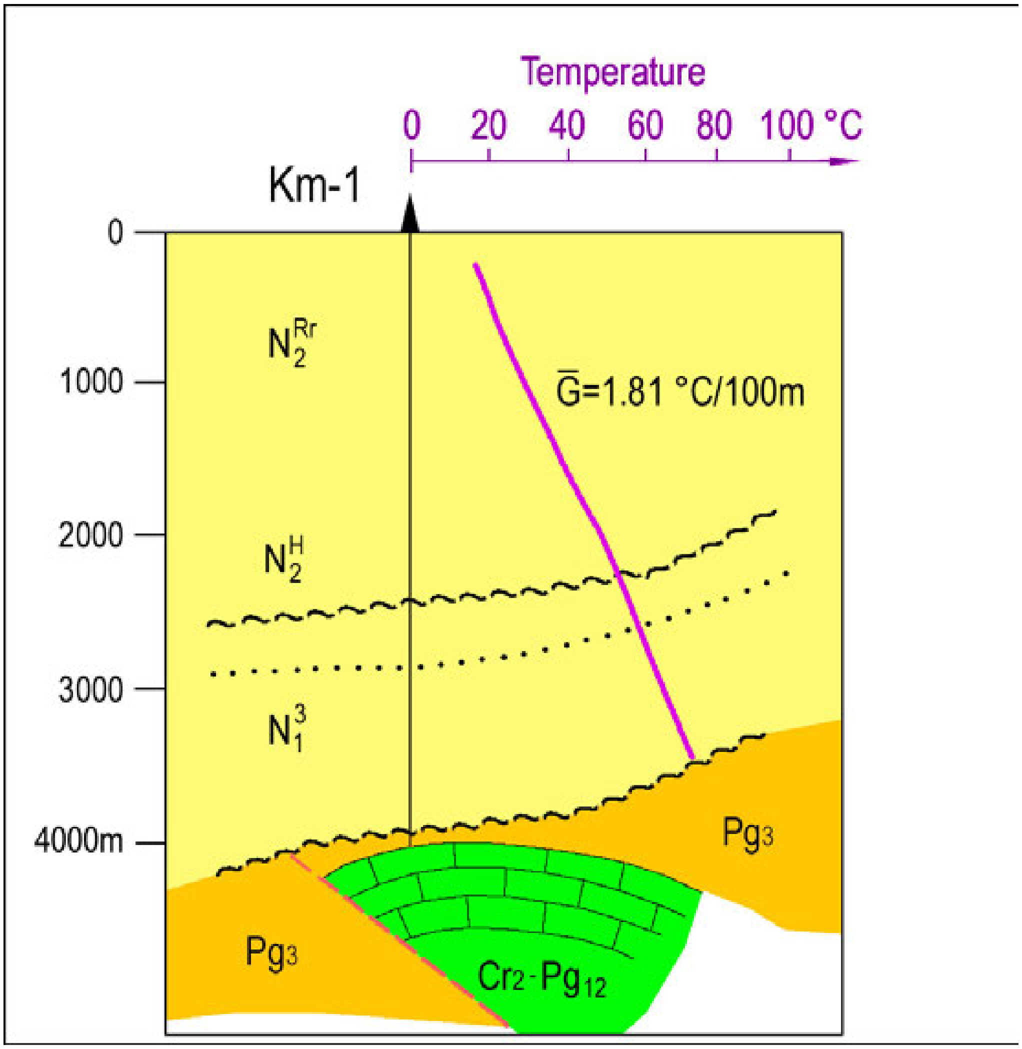


Fig. 5 - Geothermal Section Peri-Adriatic Depression

The SEG International Exposition and 79th Annual Meeting being held in Houston, Texas
25-30 October 2009.

THE USE OF GEOPHYSICAL METHODS IN SEARCH FOR CHROME DEPOSITS

The Geophysical methods, as a part of geological complex in search for chrome deposits, have to solve two main problems:

1. To conduct direct exploration for ore bodies.
2. To help in the geological-structural mapping in order to study the factors that control the mineralization.

In Albania was gained a good experience for the geophysical exploration of chrome deposits and were set up integrated methods to be used in ground and underground surveys. These are achievements of a collective body of geophysicists and geologists. These achievements have been published and presented in scientific sessions, dissertations, and in many geological and geophysical studies and projects (see references). In this monograph are generally presented the best achievements, especially those of the last ten years, carried out by specialists of the Geophysical-Geochemical Exploration Centre of Tirana.

The geophysical complex for direct search includes surface mapping by gravity, magnetic and IP methods, and the electrical and underground surveying. Underground surveying was carried out for the search around mine works and bore holes. In order to get the geophysical documentation of the boreholes, are observed the magnetic field, the gravitational field, the IP, the electromagnetic waves, the scattered gamma radiation and the neutron activation.

4.1. View on the geology of chrome ore deposits in Albania

The big ophiolitic belt of Albanides, with ultramaphic massifs, is the main belt of chrome ore deposits in Albania. In 1984 Albania was ranked at the third place in the world for exploitation of chrome ore, reaching an amount of 960,000 ton/year.

Chrome ore deposits are concentrated in the eastern ultramaphic belt (Figs. 4.1, 4.2, 4.3), with two sequences of different geological-petrological-geochemical and metallogenic sequences, in lower part of geological cross-section in about 1000 - 2000m thickness and that of cumulate sequence, over tectonic one, is about 500 - 1000m thickness (fig. 4.4).

The lower part of tectonic sequence represents the hartzburgite facies with dunitic alternation, composed of fresh rocks in the lower levels up to medium serpentinized rocks in upper levels. The dunites represent lenses of thickness of some meters, stretching over hundreds of meters. These alternations represent 10-15 % of the rock mass. A narrow alternated hartzburgite-dunitic facie, with

metallurgic chromite, is situated over the hartzburgite. Podimorf ore bodies as pseudostratos folded, lens, and column types, have rather big dip angle.

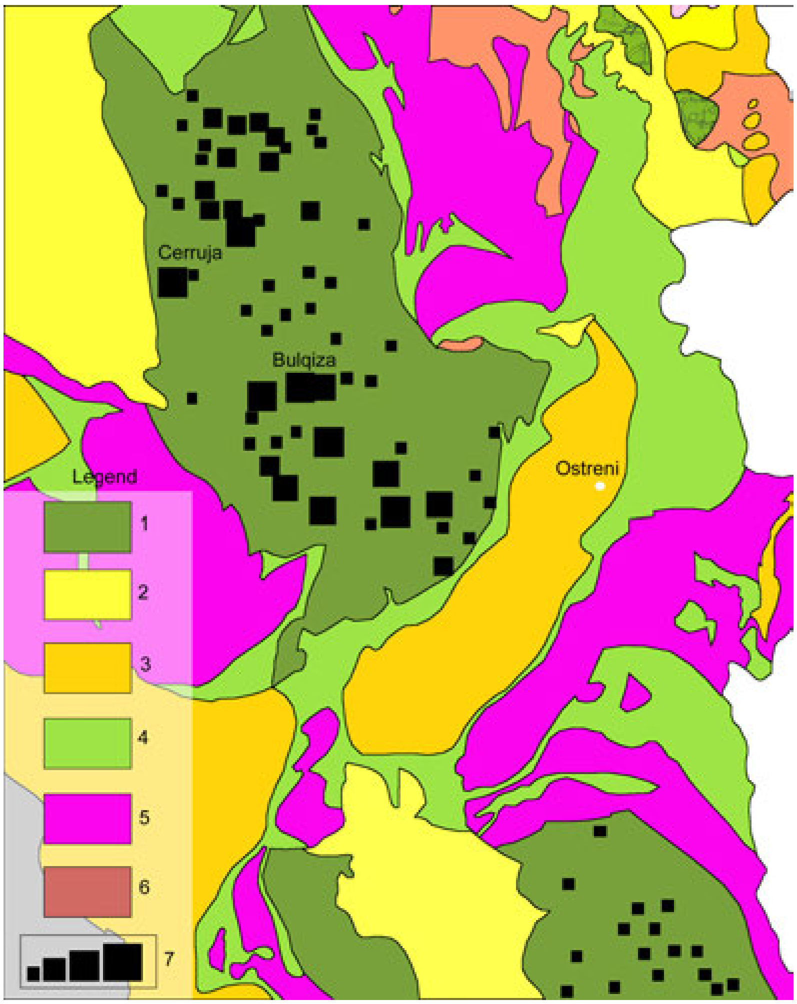


Fig. 4.1. Chromite ore deposits in Bulqiza ultrabasic massif.
(After Metalogenic map of Albania, at scale 1:200.000, 1999)
1-Ophiolitic formation; 2- Neogenic molasse formation of the post frontal depressions; 3- Maastrichtian-Eocene flysch formation; 4- Upper Tithonian-Cenomanian Early flysch formation 5- Middle Triasic-Lower Jurassic Carbonate formation; 6- Terrigeneous metamorphosed Paleozoic formation; 7- Chromites ore deposits (occurrence, small, medium, and big deposits.

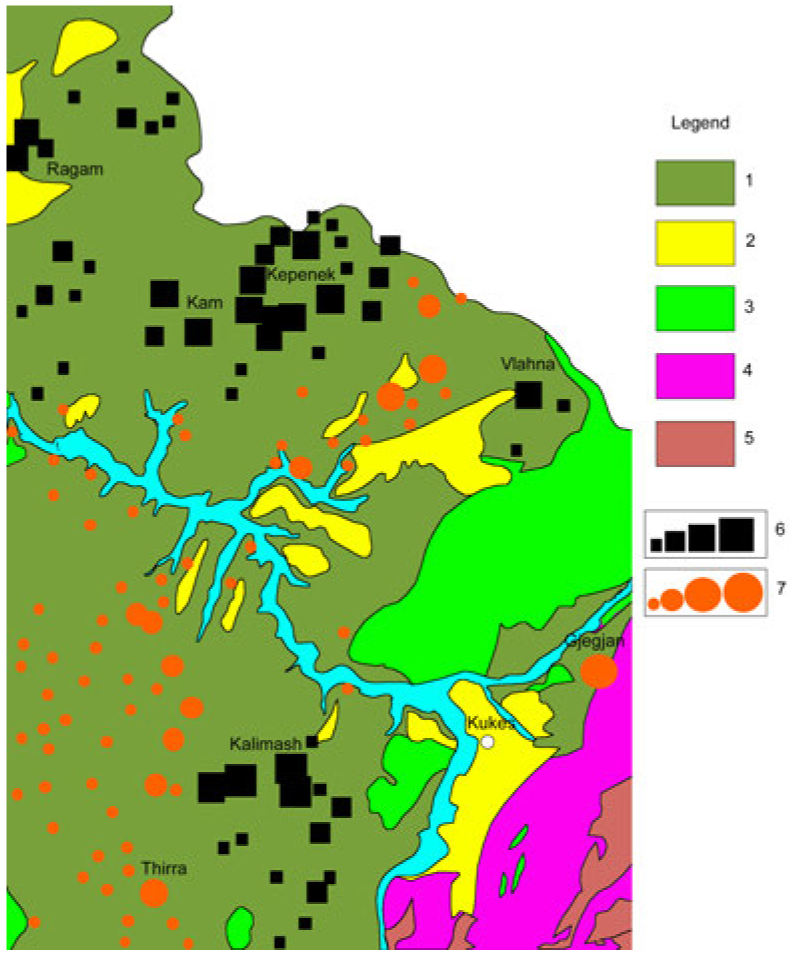


Fig. 4.2. Chromite and copper ore deposits in Tropoja-Kukësi ultrabasic massif. (After Metalogenic map of Albania, at scale 1:200.000, 1999) .

1- Ohiolitic complex; 2- Neogenic molasse formation of the post frontal depressions; 3- Barremian-Upper Cretaous carbonate formation; 4- Middle Triasic-Lower Jurassic carbonate formation; 5- Terrigeneous metamorphosed Paleozoic formation; 6-7- Chromites and copper ore deposits, respectively (occurrence, small, medium, and big deposits).

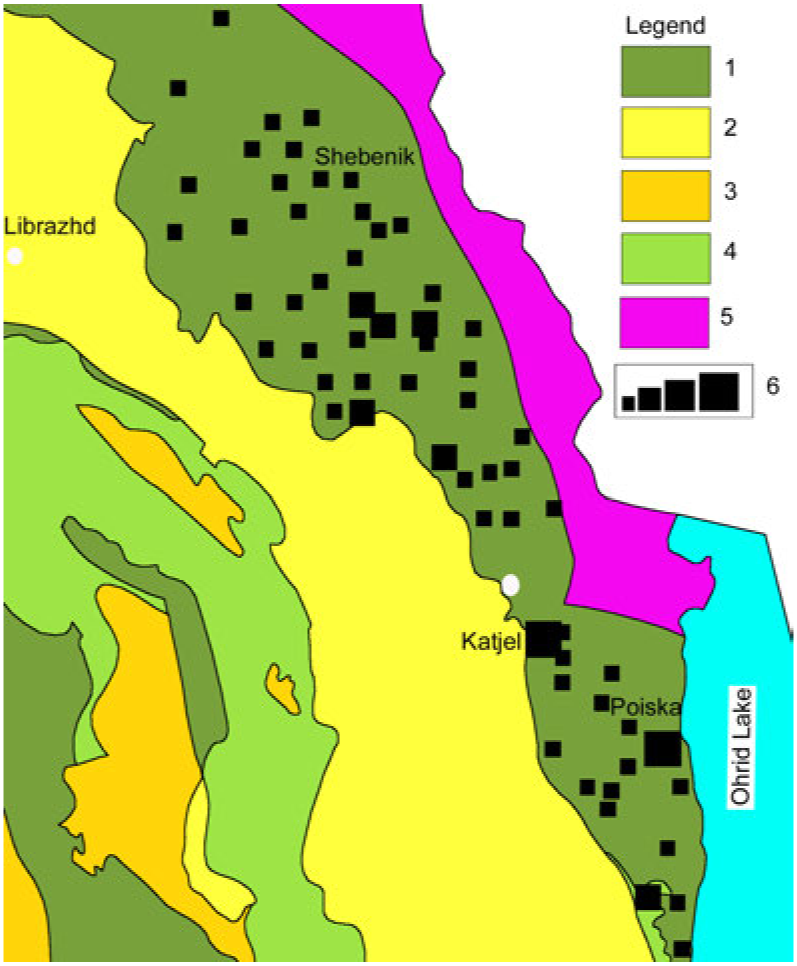


Fig. 4.3. Chromite ore deposits in South Bulqiza and Shebenik-Pogradeci ultrabasic massif. (After Metalogenic map of Albania, at scale 1:200.000, 1999). 1- Ohiolitic complex; 2- Neogenic molasse formation of the post frontal depressions; 3- Maastrichtian-Eocene flysch formation; 4- Barremian-Upper Cretaous carbo-nate formation; 5- Middle Triasic-Lower Jurassic carbonate formation; 6- Chromites ore deposits, respecti- vely (occurrence, small, medium, and big deposits).

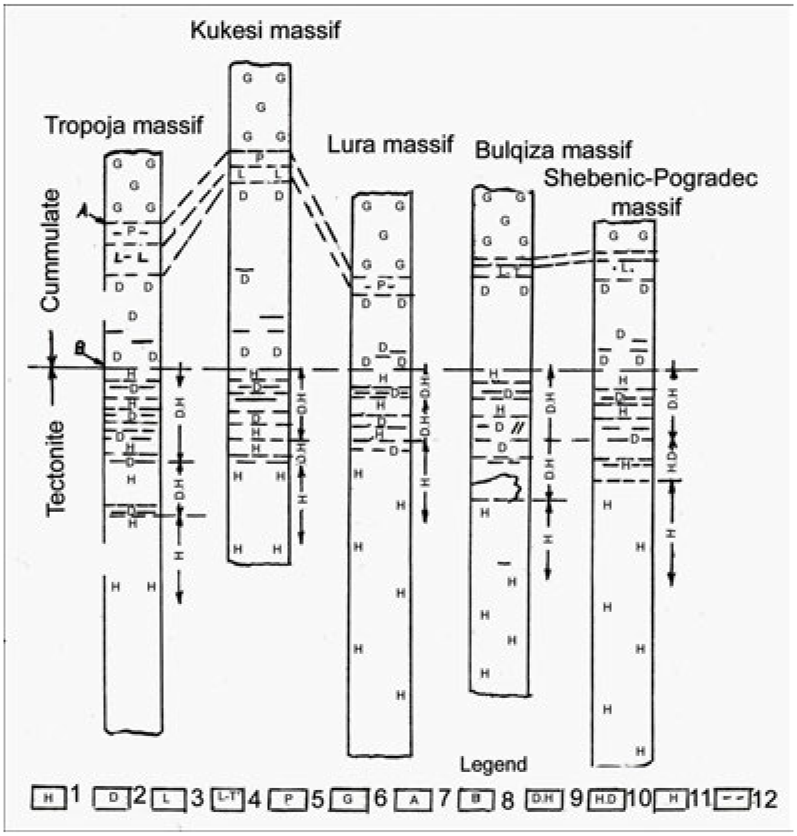


Fig. 4.4. The correlation scheme of the schematic geo-logical sections of the eastern belt of ultramaphic rocks (Hallaçi H. et al, 1989).

1- Hartzburgite; 2- Dunite; 3- Lherzolite; 4- Lherzolite-troctolite; 5- Pyroxenite; 6- Gabbro; 7- MOHO velocity discontinuity; 8- MOHO petrological discontinuity;

9- Dunitic-hartzburgite facies of tectonites;

10- Hartzburgite-dunitic facies of tectonites;

11- Hartzburgite facies of tectonites;

12- Mineralization levels.

In some deposits, the horizons of the mineralization are represented as anticlines or synclines. In some others as overlapped monoclines in different hypsometric levels are observed. Their dunitic envelopes have a thickness of some centimetres up to some tens of meters. The borders between the dunite and ore bodies are very well defined. The chrome-ore content is characterised by big amounts of Mg and little amounts of Al and Fe. The values of the ratios Cr/(Cr+Al) are 0.76-0.84 and those of Fe/(Fe+Mg) are 0.28-0.35. The ore's texture is represented as massive, nodular and disseminated one. The content of chrome oxide in high grade chromite is about 42-44 % and about 20 % in low grade chromite. It depends on the thickness of the ore body, as well. Massive texture ores are mainly situated in the central part of their bodies, as in Bulqiza, Kalimash, Kepenek and Zogaj deposits (fig. 4.5).

The dunite-hartzburgite facies is step by step situated over the hartzburgite-dunitic ones. The content and the number of dunitic alternations increases from the bottom to its top in dunite – hartzburgite facies.
The mineralization is connected with these dunitic alternations, and these ore alternations represent the main level of the mineralization.

The thickness of the ore bodies, stretching from some tens of meters to some hundreds of meters, (in some cases up to 1550 meters) varies from 0.5 up to 5-10 meters, dipping down to 200 - 400m.

The cumulate sequence is situated with angular unconformity over tectonite (petrological MOHO). The dunite with rare alternations of hartzburgite and lherzolite are predominant inside this sequence**.** Chromite in its lower levels becomes more aluminite than in higher levels.

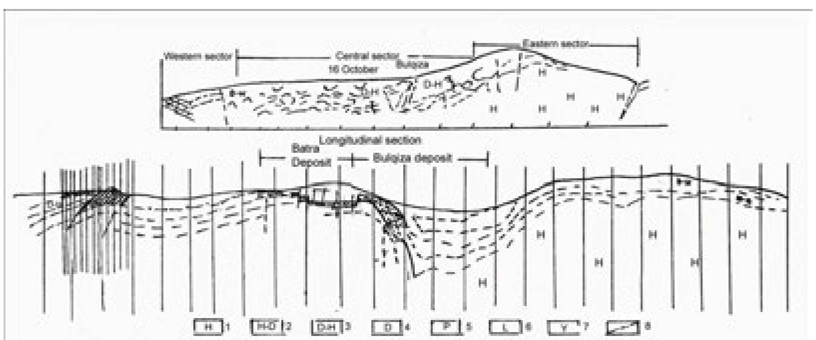


Fig. 4.5. Geological transversal (EW) and longitudinal (NS) sections in the Bulqiza ultramaphic massif (Hallaçi H. et al.1989).
1- Hartzburgite; 2- Hartzburgite-dunite; 3- Dunite-hartzburgite; 4.-Dunite; 5. Mineralization levels.

Metamorphic chromite is characterised by high content of Mg and lower contents of Fe and AL. The values the of the ratio Fe/(Fe+Al) are 0.30 - 0.40 and those of Cr/(Cr+Al) are 0.81 - 0.84. Refractory ore as alumo-chromite has a ratio value Cr/(Cr+Al) = 0.55. They are characterised by belt texture up to disseminated. Ore bodies belt morphology is presented by the alternations of chromite with dunite and they have the form of small angle dipping lens, stretching some hundreds of meters.

In figure 4.6 is shown a cross-section of Krasta deposit in the Bulqiza ultramaphic massif.

For geological-structural mapping purposes, electric soundings have been used simultaneously with gravity and magnetic surveys. The place and the role of each of these methods depend on the geology of the site, on the contrast of the physical properties between the ore bodies and the surrounding media and on the geological problem to be solved by geophysical methods.

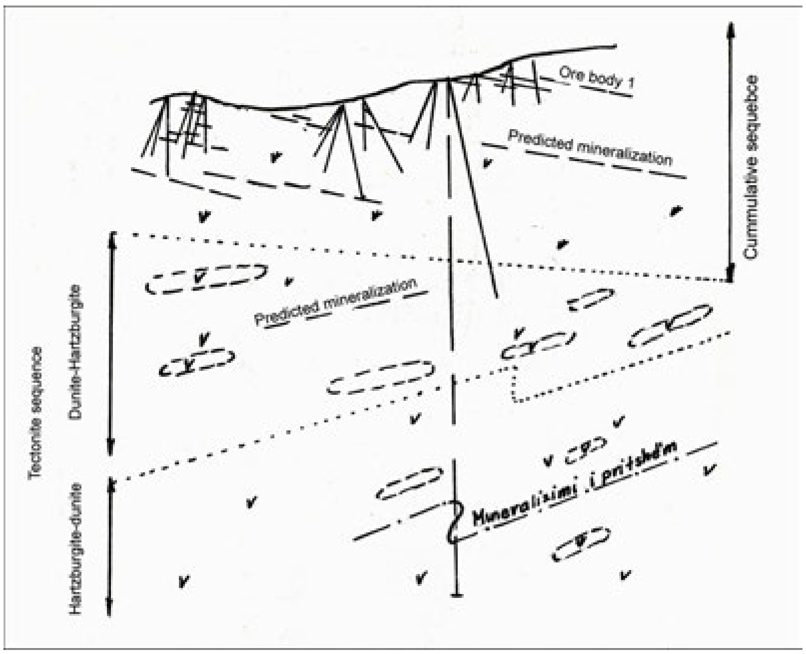


Fig. 4.6.Geological section at Krasta-Lugu Thellë deposit, Bulqiza district (Stërmasi Sh. et al. 1989).

4.2. PHYSICAL PROPERTIES OF CHROME ORES AND ULTRABASIC ROCKS

The geophysical methods in search for chrome ore deposits are mainly based on the distribution of gravitational, magnetic and electrical fields, which depend on the density, magnetism, IP and the electrical resistivity changes of the ore bodies and the surrounding rocks, and on the geology of the site, as well.

Petrophysical studies are carried out for the ultrabasic rocks of some massifs (especially those of the eastern belt) and for chrome ores, in some deposits of Albania. There are analysed the results of petrophysical studies on the density (1490 samples), magnetic (727 samples) resistivity and induced polarization (374 samples) (Frashëri A., 1974, 1989) and thousands samples by other geophysicists (Bushati S. 1997, 1998, Leka P. et al. 1988, 2002, 2004, etj.) of ultrabasic rocks and chrome iron ores.

4.2.1 Density

Iron chrome ores density

Iron-chrome ores of hartzburgites and dunite-hartzburgite of the tectonite sequence, have a density value from 2550-4380 kg/m^3. The ore's density of Kam Tropoja deposit is mostly influenced by its contain of Cr_2O_3, according to the relation:

$$\sigma = 40.C + 2000 \quad (kg/m^3) \qquad (4.1)$$

where **σ** is the density of chrome ore, in kg/m^3
C is the ore contain of Cr_2O_3 in percentage,
with a correlation coefficient of 0,92 (Fig. 3.1-a)

This relation is not a universal one. It changes from one deposit to another deposit, from one body to another body. In Vlahna deposit (Fig. 3-1-b) the correlation has following relation:

$$\sigma = 27.C + 2430 \quad (kg/m^3) \qquad (4.2)$$

Many factors are conditioned such changes of the ore density. As can be seen from figure 4-7 these regularities are different depending by contain of chrome-spinel grains.

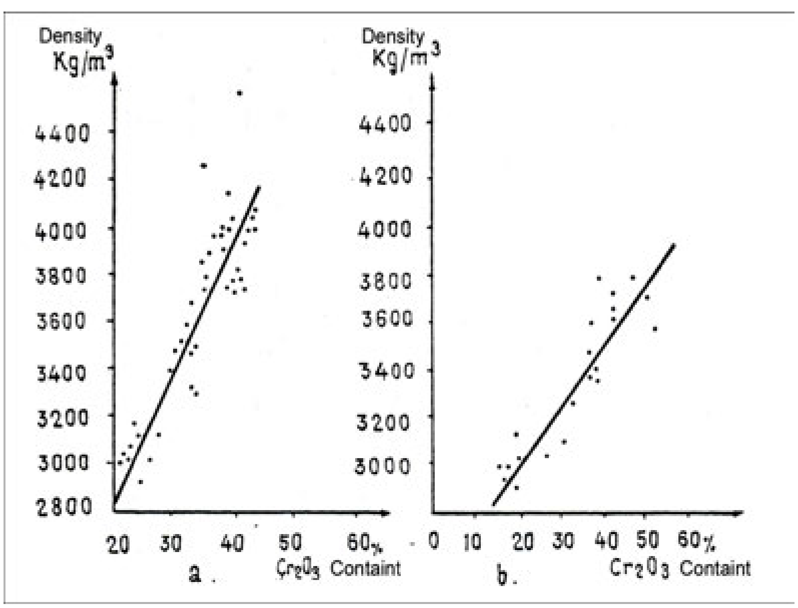


Fig. 4-7. The dependence of the chromite ore density by Cr_2O_3 contain, in Kami (1) and Vlahna (2) deposits, Tropoja ultrabasic massif (Frashëri A., 1974, 1989).

Fig. 4-8 shows the plot of the density versus the ratio Cr_2O_3/FeO value. Relation (4.1) and (4.2) show that they depend by contain of Cr_2O_3, which is the main factor, and the density of chrome spinel as well.

Table 4-1

Physical properties of chrome ores and ultramafic rocks.
(Pumo E., Frasheri A. , Tashko A. 1994)

		Density, in kg/m³			Magnetic properties in × 10^{-5} SI Units: Suscept	
No	Sample	Min	Max	Mode	Min	Ma
1	Chrome	2450	4380	3700	10	50 300
2	Dunite	2700	3340	3020	10	100
3	Serpentinized dunite	2600	2800	2700	40	300
4	Harzburgite	2800	3300	3050	10	70
5	Serpentized Harzburgite	2700	2900	2800	20	100
6	Serpentinite	2240	2650	2550	10	800
7	Pyroxenite	2900	3200	3080	10	32

* Ores with high content of secondary magnetite.

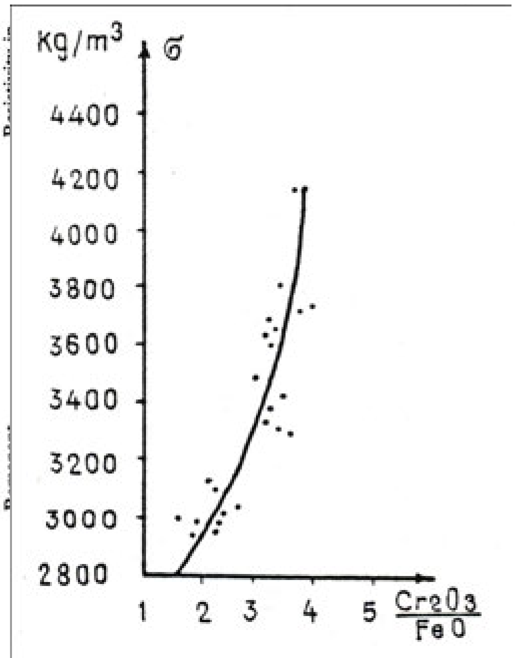


Fig ore by Cr_2O_3/FeO ratio

the the ore, also conditions of present in the tables 4.2, 4.

Density of iron chrome ores from different deposits and occurences in Tropoja utrabasic massif (Frashëri A., 1974)

Table 4.2

Deposit or occurrence	Ore structure	Density In g/cm^3	Contain (atomic units)			
			Cr	Fe^{+3}	Fe^{+2}	Magne-tic Compo-nents
Ragam	Nodular	4.3714	1.942	0.867	2.348	5.40
Tplanë	Nodular	4.4413	12.835	0.576	2.646	3.60
Pac-Çorraj	Nodular	4.4741	11.748	1.129	3.815	7.05
Pac-Çorraj	Compact	4.5902	10.974	1.524	4.713	9.50
Kam	Compact	4.4340	11.358	0.904	2.998	5.65
Kam	Compact	4.4819	11.634	1.228	3.526	7.70
Kam	Nodular	4.4294	12.062	0.862	2.705	5.40

The dependence of chrome ore density by the structure, Vlahna deposit (Frashëri A., 1974, 1989).

Table 4.3.

Ore structure	Predominant density values, kg/m^3	Cr_2O_3 contain, in %	Chrom-spinel contain, in %
Rare disseminates	2960	19.97	10
Medium	3480	37.94	50
disseminates	3800	47.89	72.5
Dense disseminates	4140	61.44	96
Massive ore	3410	38.13	40
Nodular ore	3040	27.49	40
Banded ore			

Fig. 4-9 shows distribution curve of the density of chrome spinel ore from different parts of ore body Nr.6, Kam deposit.

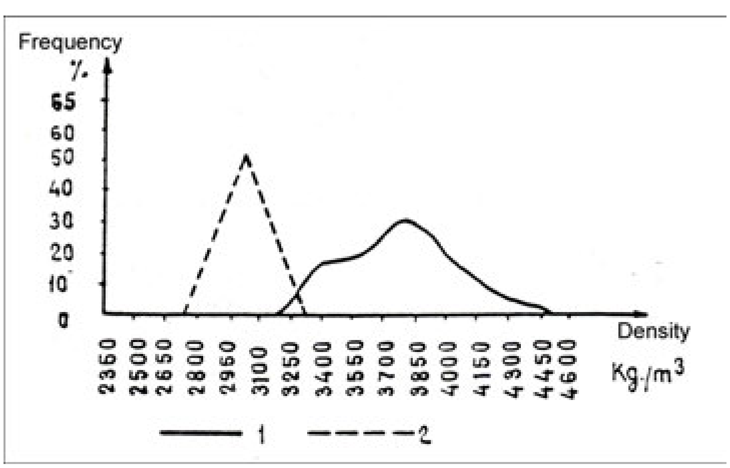


Fig. 4-9. Variation curve of the density of chrome spinel ore from different parts of ore body Nr.6, Kam deposit. (Frashëri A., 1974). 1- Rich ore (123 samples); 2- Average contain ore (96 samples)

The density of the chrome ore is conditioned by the degree of the serpentinization of its olivine. As higher is the degree of serpentinization, the smaller are the density values (fig. 4-10).

Due to all those factors, ore density values are different not only in the same deposit but in the same kind of ore as well (fig. 4-11).

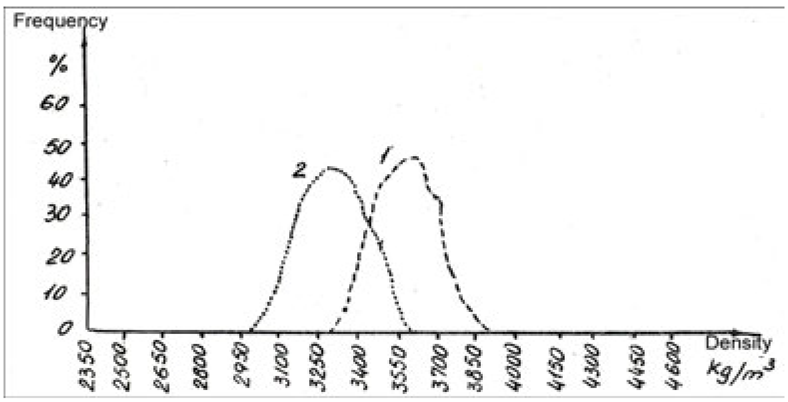


Fig. 4-10. The density variation curves of the chrome ore in the tectonic sequence, which contains olivine with different degree of serpentinization.
1- Ore between dunites, 2- Ore between serpentinized dunites.

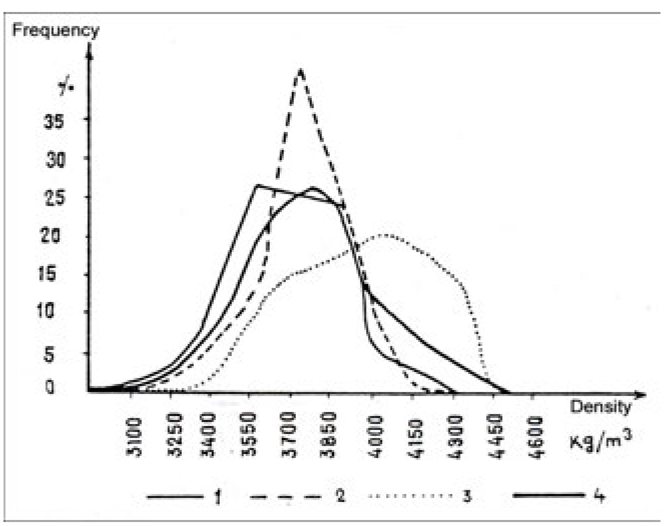


Fig. 4-11. The density variation curves of the chrome ore in different parts of the ore body, Tplanë occurrence. (Frashëri A., 1974, 1989).

1- Northern part (110 samples), 2- Central part (103 samples), 3- Southern part (101 samples),
4- Generalised curve.

The high value of the Tplanë occurrence ore's density, with high percentage of Cr_2O_3 contain, can be explained by the great density of chrome spinel (4441.3 kg/m^{3}) (Table 4.1.) and by the lack of the metamorphism of the studied ore body in which the olivine is not serpentinized.

The density of chrome-iron ore, which is connected with cumulate sequence of the rocks, changes in a wide range (Table 4.3).

The mode of the chromite from Kepeneku deposit, with dense disseminates structure up to massive, is 3,62 g/cm^3 (Fig. 4-12). The density of the chromite ores among the serpentinized rocks has a mode 3,28 g/cm^3, because the olivine of the ores is serpentinized.

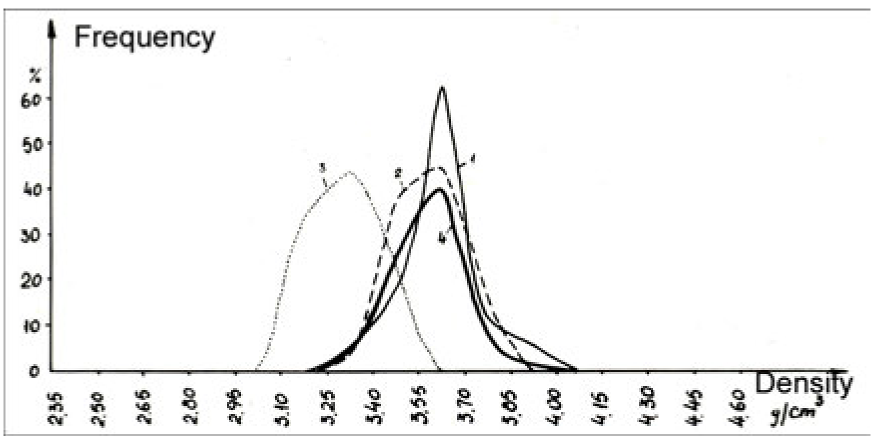


Fig. 4-12. The density variation curves of the chrome ore in Kepenek deposit. (Frashëri A., 1974, 1989).

1 - Ore of the body No. 1 (40 samples); 2- Ore among the dunites, body No. 7 (27 samples); Ore among the serpentinized rocks, body No. 7 (30 samples); 4- Generalized curve of the ore among the fresh dunites.

The chromite ores ore body 1 of the Ragami deposit have a structure by average disseminates and nodular of body Ragam. The nodules are disseminated in the partial seprpentinized mass of the olivines (seprentine of the chryzotil kind). As shows the fig. 4-13, the chromite ores from these deposits have smaller density, in comparison by the chromites from other deposits, in Tropoja ultrabasic massif.

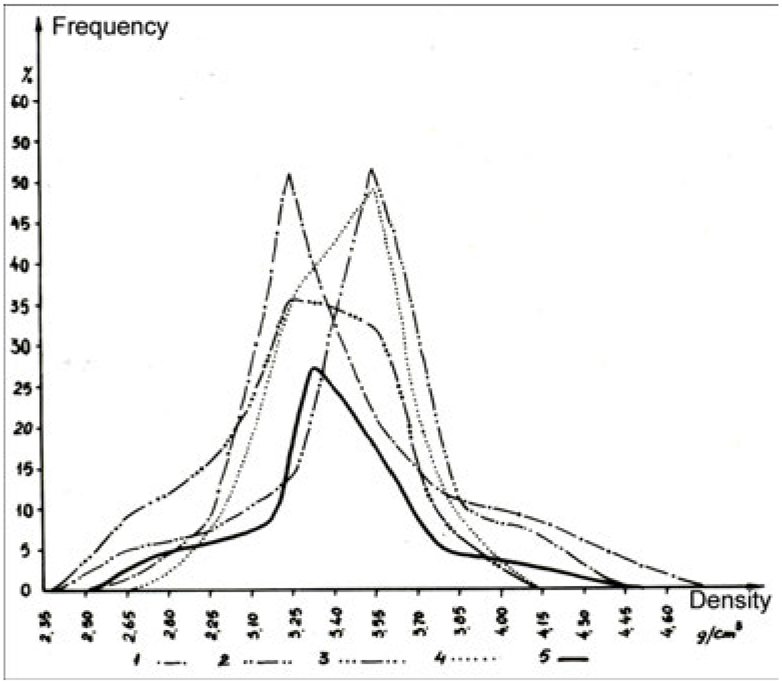


Fig. 4-13. The density variation curves of the chrome ore in different parts of ore body, Ragami deposit. (Frashëri A., 1974, 1989).

1- Ore of the body No. 1 (Ragami II) (57 sampes); 2- Ore of the body No. 2 (Ragami II) (29 samples); 3- Ore from body No. 3 (Ragami II) (31 samples); 4-Ore from Ragami I (25 samples); 5- Generalised curve.

Comparing the generalized distribution function for rich chromite of different deposits, it is noticed that density has its characteristics distribution in every deposit (fig. 4-14).

In fig. 4-15 and 4-16 are shown the density distribution curves of the chrome ore in some deposits of Tropoja and Bulqiza ultramaphic massifs.

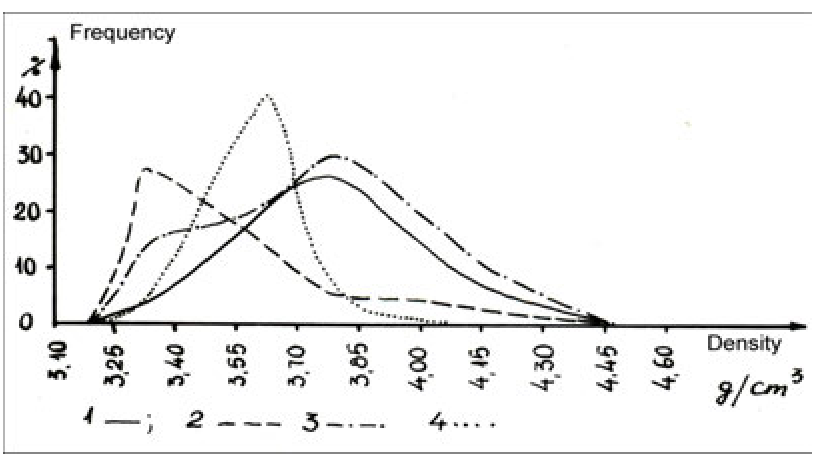


Fig. 4-14. Generalized variation curves of the density of rich chrome spinel ores of different deposits. (Frashëri A., 1974, 1989).

Characteristic of the petrodensity of chrome spinel ore and ultrabasic rocks.
(Frashëri A., 1974, 1989).
Table 4.4

Kind of ore and rocks	Nr. of samples	Density, in kg/m^3		
		Min.	Max.	Mode
1. Rich chromite, δ >3250 kg/m^3	720	3260	4380	3730±20
2. Chromite with average contain 2800< δ >3250 kg/m^3	136	2830	3250	3040±40
3. Poor chromite 2500< δ >2800 kg/m^3	13	2550	2790	2700±80
4. Dunites	101	2820	3340	2910±40
5.Serpentinized dunites	46	2650	2790	2620±20
6. Serpentinites from dunites	182	2220	2640	2570±30
7. Hartzurgites	164	2800	3330	3000±40
8. Serpentinized hartzburgites	33	2660	2800	2690±80
9. Serpentinites from hartzburgites	31	2200	2650	2580±50
10. Pyroxenites	4	2640	3320	3080±260
11, Gabro-pegmatites	10	2560	3150	3070±160

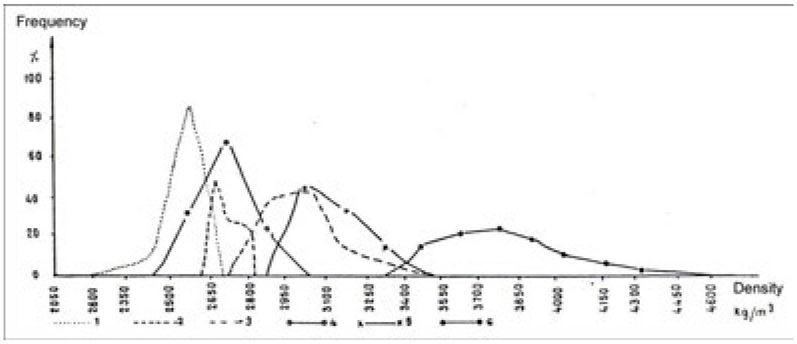


Fig. 4-15. Generalised curves of the density variations of the chrome ore and the ultramaphic rocks of the Tropoja massif tectonic sequence. (Frashëri A., 1974, 1989).

1- Serpentinite, 2- Serpentinized ultra-maphic rocks,
3- Dunites and fresh hartzburgites, 4- Ore of rare disse-minated structure, 5- Ore of medium disseminated structure, 6- Ore of dense disseminates or massive.

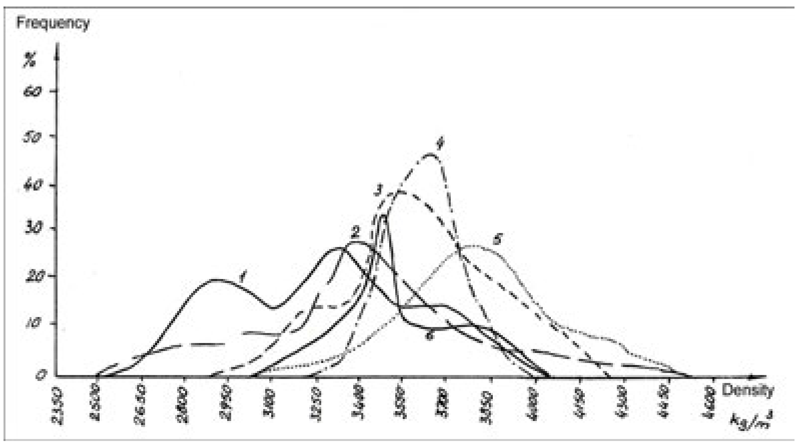


Fig. 4-16. The density variation curves of the chromi-te ores in deposits of Bulqiza and Tropoja ultra-maphic massifs. (Frashëri A., 1974, 1989, Pumo E. et al. 1994).

1- Bulqiza (plotted according to the data given by Bushati S., Karcanaj P. 1988) 2- Ragami, 3- Kami, 4- Kepeneku, 5- Tplanë, 6- Cërruja.

Based on generalised results of the study on chrome ore density in Albanian deposits, we can divide them into three categories, which have different density values:

1. Rich chromites, with 42% of Cr_2O_3 contain and with the highest density value, which varies form 3260 - 4380 kg/m^3. The predominant density value is 3730 kg/m^3 corresponding to chrome ores with 42% of Cr_2O_3.
2. Chromites with average contain of chrome oxide Cr_2O_3 of 32-42% and density values of 3200 - 3680 kg/m^3. The predominant density value is 3300 kg/m^3 corresponding to chrome ores with 32.5% of Cr_2O_3 contain.
3. Low contain of chromites, with 12.5-30.0% of Cr_2O_3 contain and low-density values of 2550 - 3200 kg/m^3. The predominant density value is 2700 kg/m^3 corresponding to chrome ores with 17.5% of Cr_2O_3 contain.

Ultrabasic rocks density

The study of the density of the ultrabasic rocks was carried out according to their classification in fresh and serpentinized dunites and hartzburgites, pyroxenites and the kinds of vein series (Dede S. 1865, Dobi A. 1981, Ndoja I. Gj. 1961, 1988, Shallo M. et al. 1989).

The density values of the ultrabasic rocks of tectonic sequence of hartzburgites and dunitic hartzburgites are between 2200 and 3340 kg/m^3.

The studies dunites have simple mineralogical composition. Mainly olivine and chrome spinel takes part as accessory. The highest density value of 3340 kg/m^3 is characteristic for fresh compact dunites (Photo 4.1). In figure 4.16 is shown the density distribution curve of the dunites in the ultramaphic massif of Tropoja. In the dunites group, besides the fresh rocks (with 0-5% of serpentine) are also included little serpentinized rocks (with 10-15% serpentine) with a predominant density value of 2910 kg/m^3.

Serpentinized dunites can be distinguished by the predominant density value of 2680 kg/m^3. For this types of rocks the contain of serpentine ranges from 15-20% up to 50%.

This decrease of density values can be explained by the fact that chrysotile and antigorite, created during the transformation of the olivine in the process of the serpentinization, have density values from 2500-2700 kg/m^3, which are lower than the density values of the olivine from 3300-3500 kg/m^3. The high number of cracks in the rocks can also explain such decrease of the density.

In the figs. 4-17 and 4-18 is also shown the distribution curves of the density values of the ultrabasic rocks of Bulqiza and Tropoja massifs, particularly and rocks of cumulate sequence in Cerruja area (Bulqiza). The density values of the hartzburgites and the serpentinized hartz-burgites are the same with those mentioned above. The studies hartzburgites have an average composition of 60-70% olivine, 30-40% rhombic pyroxene, 1% chrome spinel, serpentine and very rarely some grains of monoclyne pyroxene (Photo 4-2).

Though the density of hartzburgites varies within the sae limits as the density of dunites we notice that the maximum in the distribution curve of hartzburgites density shifts on the right, i.e. they have a density mode of 3000 kg/m^3, which is greater than that of dunites.

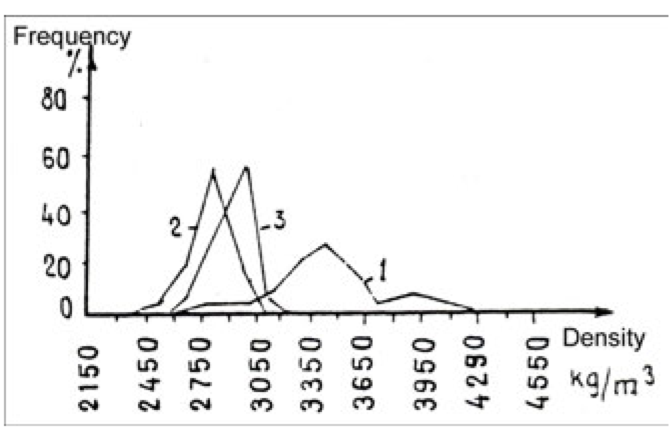


Fig. 4-17. Variation curves of the density of chrome spinel ore
(1), dunites
(2) and hartzburigites
(3), Ragami deposit. (Frashëri A., 1974).

As it can be seen from the distribution curves in figures 4-15 and 4-18, it seems that the dunites of tectonic sequence have a predominant density value of 1500 kg/m^3 lower than the hartzburgites. This shows that the dunites are more serpentinized than the hartzburgites, even though they are situated in the same conditions.

The average densities of dunites and hartzburgites of cumulate sequence are almost even, but however, the densities of hartzburgites are characterised by a higher variation factor, which indicates that these rocks have different degrees of serpentinization. The top density value of 3180 kg/m^3 shows about the existence of lower serpentinized hartzburgites than dunites. There were no defined density borders between dunites and hartzburgites of cumulate sequence in Cerruja deposit.

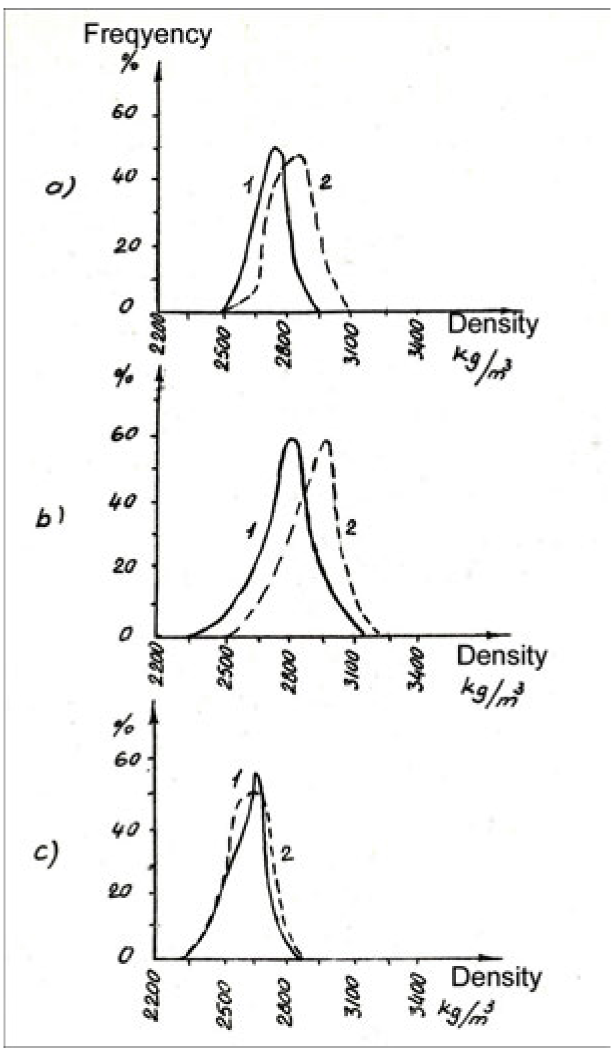


Fig. 4-18. The density variation curves of the dunite (1) and hartzburgite (2) of tectonic hartzburgite sequence and dunitic-hartzburgite one of the Bulqiza massif (a) (Bushati S. etc.), of Rragami massif (Tropoja) (b) and of cumulate sequence in Cerruje (Bulqiza) (c) (Frashëri A. 1974).

Petrographic studies have demonstrated that the dunite rocks, which the fissures constitute 10-15% to 20% of the rock volume, has a density values of 3000 kg/m^2, though they may be unserpentinized.

The pyroxenites and gabbro-pegmatites have high density values. The predominant density values of pyroxenites and gabbro-pegmatites are respectively 3080 kg/m^3 and 3070 kg/m^3

The serpentinites have lower density values than all the kinds of ultramaphic rocks even if they are of dunite or hartzburgite origin (fig. 4-15). The predominant density value of serpentinite is 2570 kg/m^3 (Photo 4-3). Serpentinite with smaller density values than chrysotile and antigorite (2200 kg/m^3), which represent 90% of rock mass, can be found as well. The porosity and the fissures, especially in the serpentinites that are formed during the process of dynamo-metamorphism, can explain the decrease of density values.

Very important is comparison of the density of ultrabasic host rocks and density contrast among chrome spinel and surrounding rocks in different deposits. Dunites and hartzurgites in Tplanë deposits have the most higher values of the density, with respectively modes 3000 and 3070 kg/m^3 (Fig. 4-19).

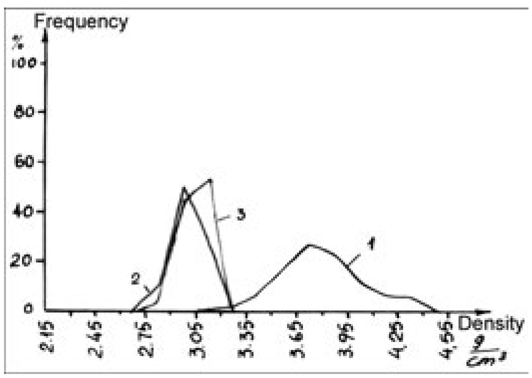


Fig. 4-19. The density variation curves of the chromites (1), dunites (2) and hartzburgites (3) in Tplanë deposit, Tropoja ultrabasic massif. (Frashëri A., 1974).

In the Ragami deposit are located also the serpentinized dunites and hartzburgites, with density smaller 2800 kg/m^3, and serpentinites (Fig. 4-20). The mode of the dunites density is 2820 kg/m^3, and of the hartzurgites 2950 kg/m^3.

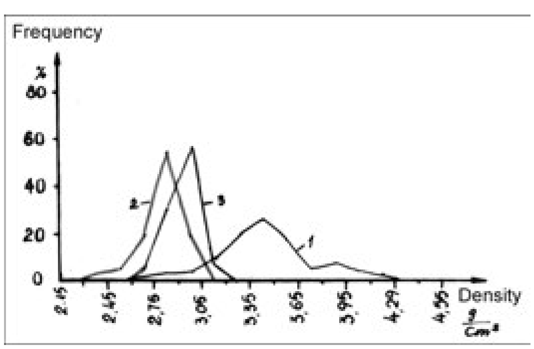


Fig. 4-20. The density variation curves of the chromites (1), dunites (2) and hartzburgites (3) in Ragami deposit, Tropoja ultrabasic massif. (Frashëri A., 1974, 1989).

Consequently, in Ragami area the dunites are most serpentinized that hartzburgites.

The density of the dunites in Kepenek deposit change from 2900 to 3040 kg/m^3, and hartzur-gites from 2550 up to 3100 kg/m^3, with a mode 3040 and 3010 kg/m^3, respectively (Fig. 4-21). Hartzburgite individualisations, near of the zone of disjunctive tectonics are presented more serpentinized.

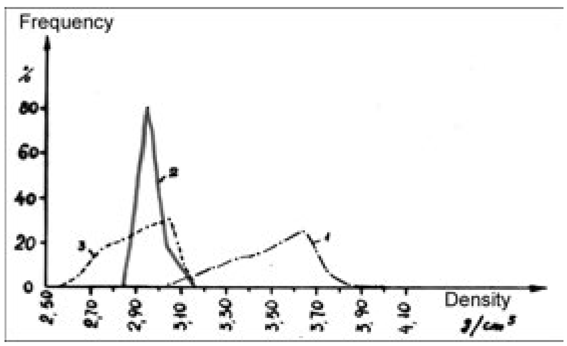


Fig. 4-21. The density variation curves of the chromites (1), dunites (2) and hartzburgites (3) in Kepenek deposit, Tropoja ultrabasic massif. (Frashëri A., 1974).

In the other deposits or occurrences in the Tropoja ultrabasic massif, the density distribution of the different kinds of the surrounding rocks, has another character. In the Kami deposit, there are extended a ultrabasic rocks with a density mode of 2530 kg/m^3, which shows the present of serpentinites.

The density of the dunites and apodunitic serpentinites change from 2480 kg/m^3 up to 3050 kg/m^3, and mode 2530 kg/m^3 (Fig. 4-21).

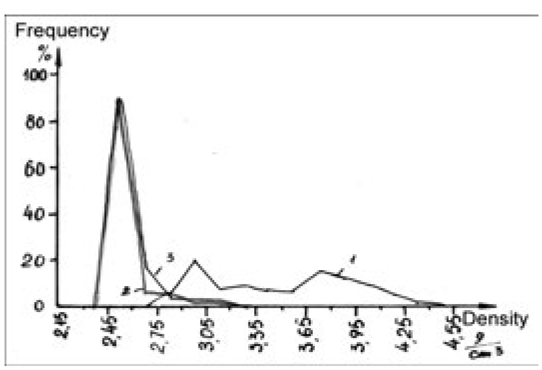


Fig 4-22. The density variation curves of the chromites (1), dunites (2) and hartzburgites (3) in Kami deposit, Tropoja ultrabasic massif. (Frashëri A., 1974).

The hartzburgites and apoharzburgitic serpentinites have a density varies from 2380 up to 2940 kg/m^3 , with mode 2540 kg/m^3.

In the Vlahna deposit, in Paci and Gzhima occurrences, predominate serpentinites with average density 2560 kg/m3 (fig 4-23, 4-24, 4-25). Only in the great depth, are located also the fresh ultrabasic rocks.

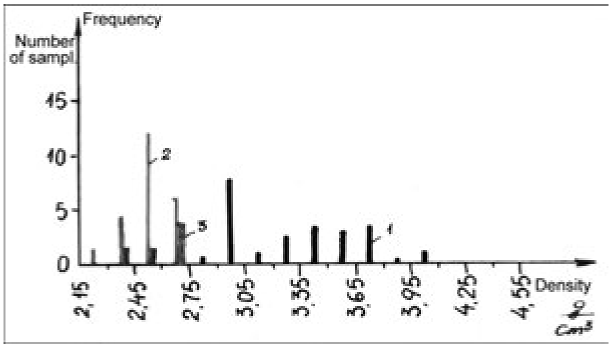


Fig. 4-23. The density variation curves of the chromites (1), dunites (2) and hartzburgites (3) in Vlahna deposit, Tropoja ultrabasic massif. (Frashëri A., 1974).

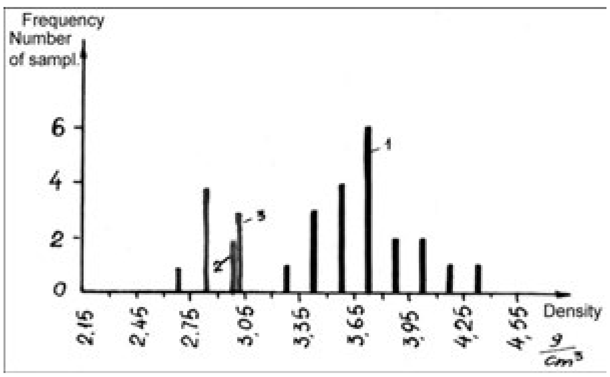


Fig. 4-24. The density variation curves of the chromites (1), dunites (2)
and hartzburgites (3) in Paci occurrence, Tropoja ultrabasic massif. (Frashëri A., 1974).

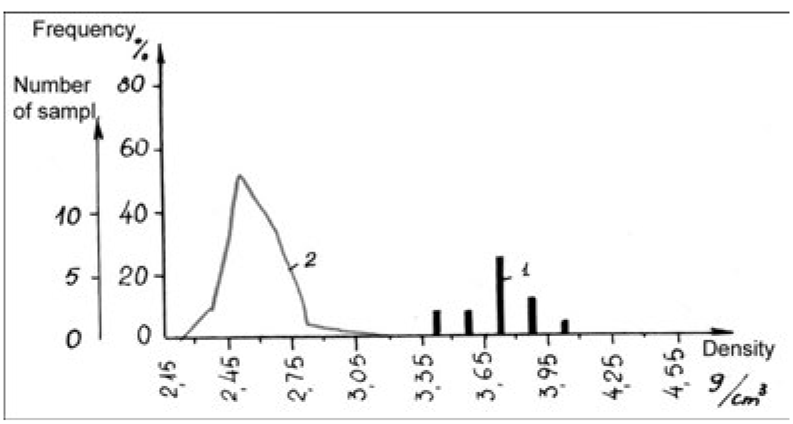


Fig. 4-25. The density variation curves of the chromites (1), dunites (2) and hartzburgites (3) in Gzhima occurrence, Tropoja ultrabasic massif. (Frashëri A., 1974).

Based on above-mentioned analyse it is possible to take some geological conclusions about the ultrabasic massif of Tropoja: Ragami deposit, Tplanë and Paci occurrences are located in the western part of the massif. Kami, Kepenek and Vlahna deposits are located in the eastern part of the massif. The density mode of

the ultrabasic rocks in the western part of the massif is averagely 2980 kg/m^3, in eastern part 2550 kg/m^3. This situation shows that in western part of the massif are extended mostly fresh ultrabasic rocks. Serpentinized dunites and hartzburgites also and the serpentinites are presented in general eastern part of the massif rocks. Consequently, from west to the east is increased the level of the serpentinization and dynamo-metamorphism. In the same time, serpentinization intensively of dunites and hartzburgites are different in these both side of the massif. Dunites of the western part of the massive are most intensively serpentinized that hartzburgites. Par counter, in the eastern part, there are hartzburgites most serpentinized. In the vertical direction, the density of the geological section rocks, in the deposits, in general, is homogeneous. Density space distribution peculiarities of the ultrabasic rocks of the Tropoja massif are expressed geological-textural settings of the massif.

Figs 4-15, 4-16, 4-19 up to 4-25 and tab. 4.5 shows the value of the density contrast among chromite spinel ores and ultrabasic rocks of the Tropoja massif.

Residual density of chromite spinel ore and ultrabasic rocks of Tropoja massif

Tab. 4.5.

Ore or rock individualisation	Surrounding rocks	Residual density and confidence borders, g/cm^3
Rich chromites	Fresh dunites and hartzburgites	800±40
	Serpentinized dunites and hartzburgites	1000±20
	Serpentinites	1100±40
Average contain of chrome spinel	Serpentinized dunites and hartzburgites, serpentinites	400±50
Piroxenites	Serpentinized dunites and hartzburgites, serpentinites	40±260
Gabbro-pegmatites	Serpentinized dunites and hartzburgites, serpentinites	400±180
Fresh dunites and hartzburgites	Serpentinized dunites and hartzburgites, serpentinites	400±40

Based on petrodensity studies, it results that chrome ores have different density values from those of the surrounding ultramaphic rocks. Massive ores are very well distinguished from surrounding rocks; medium disseminates chromites can be distinguished by serpentinized rocks and serpentinites and poor chromites are different from the last ones. Dunites and fresh hartzburgites, pyroxenites and

also gabbro-pegmatites are differentiated from all kinds of serpentinized ultramaphic rocks.

4.2.2. Magnetism

The magnetism values of the chrome ore and the ultrabasic rocks is unstable and change in a wide range. The magnetism is the most variable property of them. This is due to the quantity changes of iron-magnetite minerals and their forms inside the ore or minerals. The variation of their residual and chemical magnetism strongly depends on the chemical transformations, recrystallization and redistribution of the mechanical stresses. Therefore, chrome ores and ultrabasic rocks can be classified as nonmagnetic, weakly magnetic, and strongly magnetic ones.

Iron chrome ore magnetism

Massive texture iron-chrome ore, situated inside fresh ultrabasic rocks, has an induced magnetization (I_i) predominant value of $(500\pm50)\cdot10^{-5}$ SI units (fig. 4-26, tab. 4.6).

The remanent magnetization of those chromites varies between $(100\text{-}8100)\cdot10^{-5}$ SI units. In Kepenek deposit are found very powerful magnetic ores with a predominant remanent magnetization value of $5300\cdot10^{-5}$ SI units (Photo 4-4), and also non-magnetic ores, with I_r values $(150\text{-}70)\cdot10^{-5}$ SI units. The ores of average disseminates structure have smaller induced magnetization levels than the massive ores. The remanent magnetization in massive ores has almost equal values (Table 4.6).

From this table it can see that the ore in serpentinized rocks differs from the others. Unlike the ore i the fresh rocks, those in the serpentinized rocks are generally not magnetic.

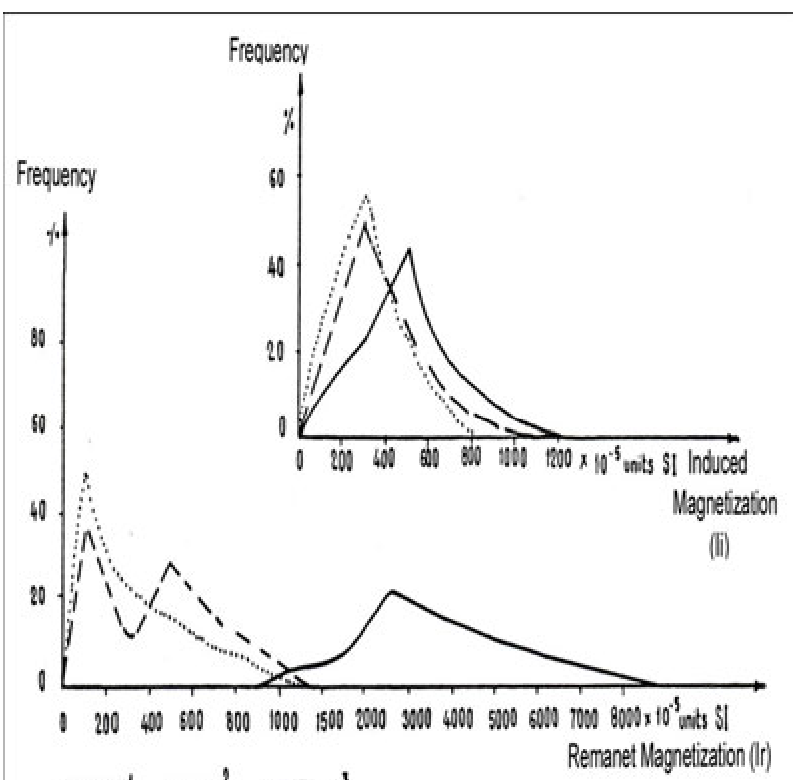


Fig. 4.26. The variation of induced magnetization (I_i) and remanent magnetization (I_r) of chrome ores and ultramaphic rocks of tectonic sequence (Frashëri A. 1974, 1989).
1- Dunites, 2- Hartzburgites, 3- Massive structure chromites.

The magnetic properties of the chrome spinel ore and the ultrabasic rocks. (Frashëri A, 1974, 1989)

Table 4.6.

Kind of ore or rock	Quantity of samples	Induced magnetization I_i, $*10^{-5}$ units (SI)			Remanent magnetization I_r, $*10^{-5}$ units (SI)		
		Min.	Max.	Mode	Min.	Max.	Mode
Chromite with structure of dense disseminated up to massive among dunites	25	100	1250	500±150	10	8100	100 700 3200
Massive magnetic chromite among dunites	8	2400	10000	3700	2400	10000	5300
Chromite with structure of average disseminated among duntes	25	100	1000	300±100	1200	6500	2500±900
Chromite among the serpentines	27	100	10000	300±100	10	900	100±80
Dunite	85* 32**	0	700	10±10 50±30 200±80	10	1800	300±70
Serpentinized dunite	20	38	1000	350			
Harzburgite	109* 56*	0	700	15±15 300±100	20	1000	300±100
Serpentinized harzburgites	87* 14**	40	1000	300	20	1300	350±150
Serpentinites from dunites	82	0	3700	150±70	5	70000	300±90
Serpentinite from harzburgites	68	0	1100	250±50	5	9500	150±60
Pyroxenites	102	10	720	350±60	10	71000	150±90
Gabbro pegmatites	21	0	270	50	170	250	

Note: * samples quantity of I_i measurement
** samples quantity of I_r measurement

The strong magnetic chromites, represent ores with 90-95% chrome spinel and 10-5% olivine contain. Their chrome-spinel appears splitted and corroded by olivine. Many thin belts of broken ores can be observed on polished sections. The

quantity of secondary magnetite is rather big in these ores. This secondary magnetite is found in the form of small spots and narrow and long veinlets almost parallel with each other, inside chrome spinel grains and in the fissures. Their induced magnetisation can be determined by the quantity contain of secondary magnetite. Due to the typical crystalline structure of spinel and to chemical formula $(Mg, Fe)(Cr, Al, Fe)_2O_4$, the chrome spinel represent the ferrite and magnetic moment of the molecule is created by bivalent atom of the iron Fe^{2+} (table 4.7).

The dependence of chromite magnetism by FeO contains.

Table 4.7

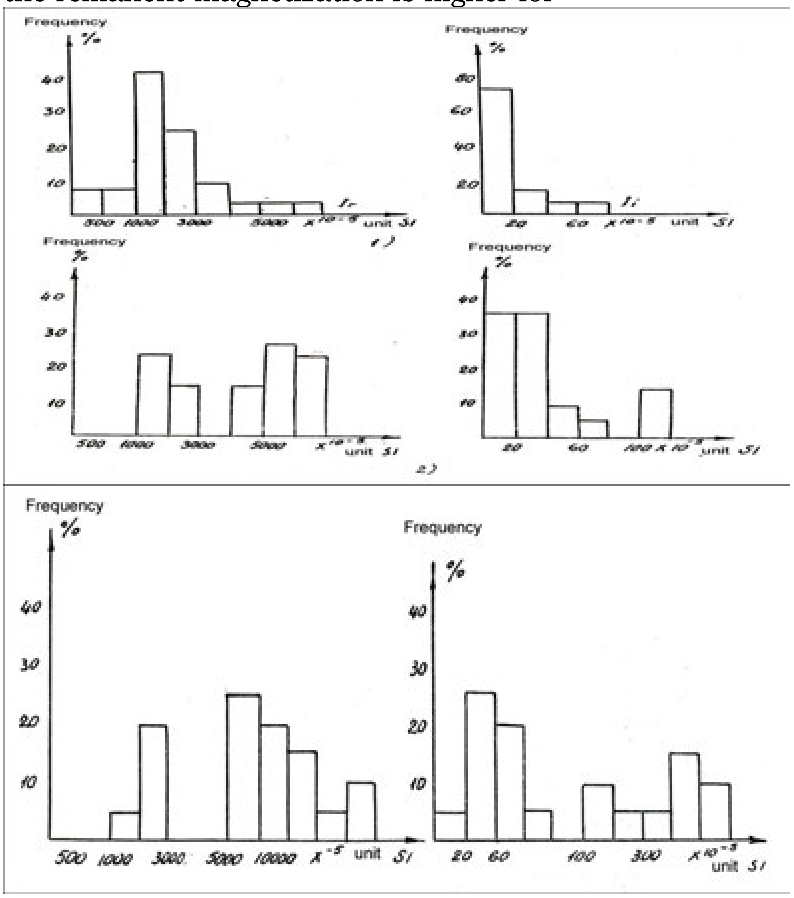
FeO contain 15%	Induced magnetization, in $x10^{-5}$ SI units	Remanent magnetization, in $x10^{-5}$ SI units
11.31	140	3517
16.07	270	3153

Chrome spinelides, behaving like ferrites have induced magnization which varies in broad limits, that depend on contain of bivalent of iron (Fe^{+2}) in their spinelic structure and on the contain of the secondary magnetite as well. Beside the contain of bivalent atom of iron (Fe^{+2}), which for the chrome spinel of the studies massif reaches averagely 3,3 atoms (Çina A., 1966), there is another characteristic linked with the contain of titanium oxide TiO (averagely 0,08 atoms) which is in just proportion with the contain of three valent atom of iron (Fe^{+3}) (Çina A. et al. 1966, Çina A. 1970, 1987). The presence of TiO_2 influences its magnetic features, as well. In general, it is proved that, the magnetization gets higher together with the increase of the number spinel grains inside the ores. Besides the induced magnetization in the chrome spinelides there exists the phenomenon of hysteresis, as the result of which there might appear remanent magnetization. So, it is natural, that the remanent magnetism has gained values with broad limits, but with maximal values smaller than the remanent magnetization of the magnetic minerals and especially of magnetite.

The larger magnetism of the massive structure ore compared with that with disseminates, is influenced even by the larger contain of Fe in massive ores.

The remanent magnetization (I_r) marked reduction down to $100x10^{-5}$ units SI, and the induced magnetization (I_i) reduction down to $300x10^{-5}$ units SI for the ores in the serpentinized rocks was accompanied by a Q_n ratio change (from $Q_n>1$ to $Q_n<1$) as well (Table 4-6). The decrease of the remanent and induced magnetization of the ores situated between serpentinized rocks can be explained by the magnetization changes of the ferrite. Elastic strain effects due to the redistribution of mechanical stresses and the chemical-mineralogical changes occurring during the serpentinization process cause these changes (Photo 4-5, 4-6).

Nevertheless the ore magnetism is not the same for different deposits. For example, the disseminated texture ore in Fushe Kalt deposit in Bulqiza ultrabasic massif has a predominant induced magnetization value of 20x10-5 units SI, while the remanent magnetization is higher for



Remanent magnetization Induced magnetization

Fig. 4-27. The histograms of the variation of the remanent (I_r) and induced (I_i) magnetization of the chrome ores in Fushe Kalt deposit in Bulqiza ultrabasic massif (plotted by data of Sharra Xh. et al. 1987, according to the measurements of Kosho P., Dema Sh., Rrenja A.).
Ore structure: 1- Average disseminates, 2- Average-Dense disseminates, 3- Massive ore.

the chromite of medium disseminates up to dense disseminates, or massive structure (Fig. 4-27). Massive chromites are not magnetic ones.

Disseminated structure ores with high values of induced magnetisation up to 850.10^{-5} units SI are located in areas, which have been under a powerful dynamic action, where a lot of secondary magnetite is created within the serpentine mass and even in the chrome spinel grains. On the contrary, the massive ores of the same zone due to small contain of magnetite in the main mass have a smaller value of induced magnetization (Ii).

In the 45% of the analysed samples remanent magnetization observed is $1<I_r/I_i<3,5$ and in special cases up to 12,5.

Remanent magnetization vacillates in broader limits than the induced magnetization; especially, for particular samples it reaches up to 97000x10^{-5} units SI.

Mineralographic studies have proved that magnetism is strengthened alongside with the increase of the chrome spinel grains in the ore.

Figs. 4-28, 4-29, and 4-30 show the distribution of the magnetization of chromite spinel ores of the Kepenek, Kam, Vlahna deposits.

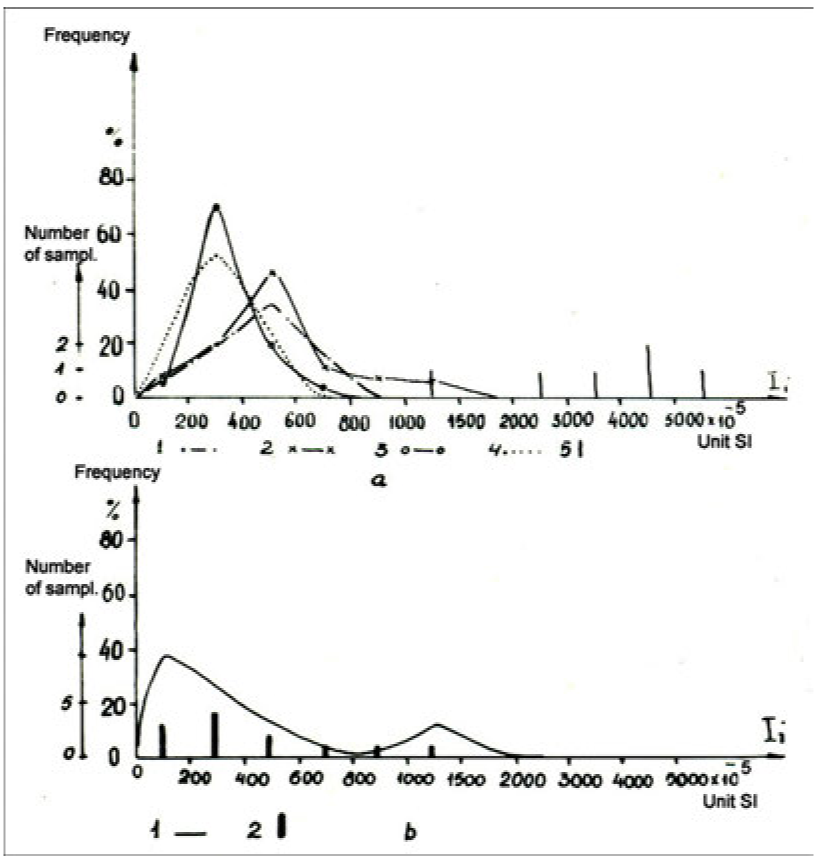


Fig. 4-28. Variation curves and histograms of the induced magnetiza-tion (I_i) of the Kepenek deposit ore (a), and Kam, Vlahna deposits and Pac occurrence (b). (Frashëri A, 1974).

1- Massive ore of the No. 1 body, which is located among the fresh dunites (26 samples); 2- Massive ore of the No. 7 body, among the fresh dunites (27 samples); 3- Ore among serpentinized rocks of Nr. 7 body (27 samples); 4- Average disseminates, among the fresh dunites (25 samples); 5- Magnetic massive ore of the No. 1 body (5 samples).

1.Rich chromite ore from Kam, Vlahna deposits and Pac occurrence (generalized curve, 33 samples);

2. Poor-average disseminated ore from Kam and Vlahna deposits (common graphic, 12 samples).

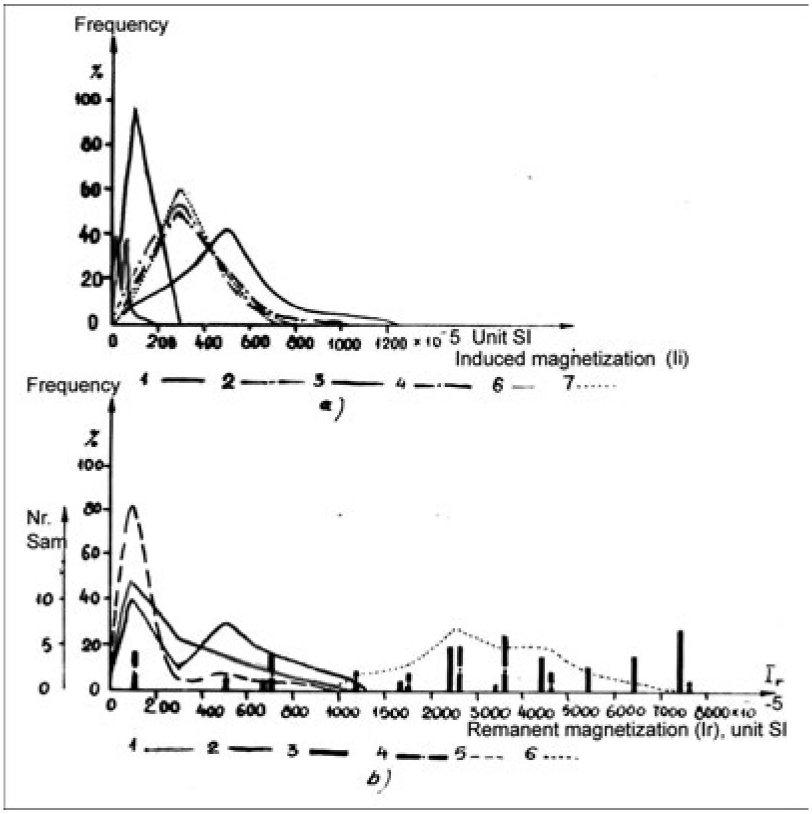


Fig.4-29. Variation curves and histograms of the induced magnetiza-tion (I_i) and remanent magnetization (I_r) for chrome spinel ores and ultrabasic rocks of the Kepenek deposits, and fresh rock of the Ragami deposit. (Frashëri A, 1974)

1- Dunites, Ragami deposit (45 samples);

2- Dunites, Kepenek deposit (30 samples); 3- Hartzburgites, Ragami deposits (58 samples); 5- Massive chrom spinel ore among the fresh dunites, Kepenek deposit (48 samples); 6- Chrome spinel ore among the serpentinized rocks, Kepenek deposit (52 samples).

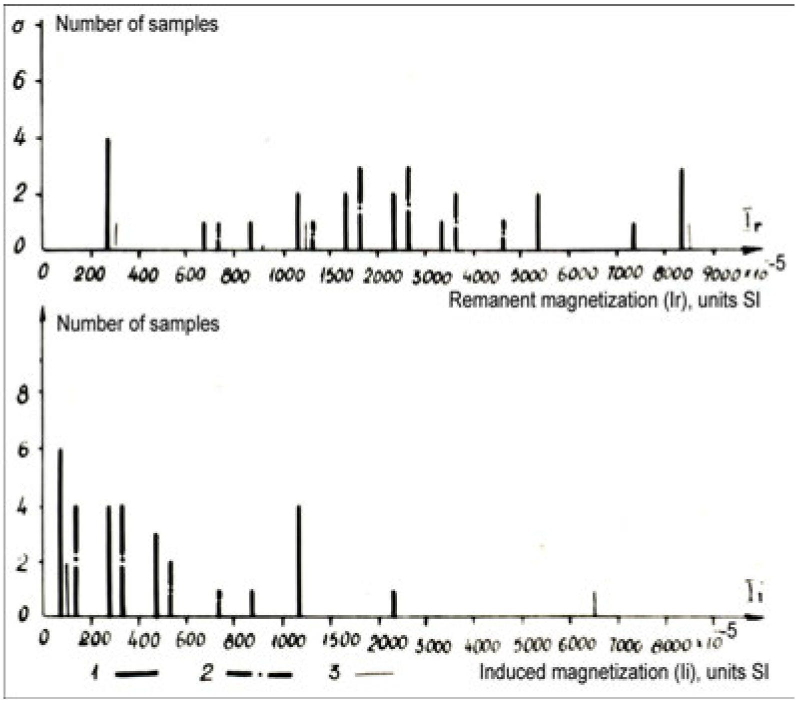


Fig.4-30.Histogrames of the induced (I_i) and remanent (I_r) magnetization of the rich chrome spinel ores from Kam (1), Vlahna (2) deposits, and Pac occurrence (3). (Frashëri A, 1974).

Magnetism of the rocks

The ultrabasic rocks have a magnetism, which changes in a broad band, conditioned by the presence of the ferromagnetic minerals, mainly by secondary magnetite and less by the magnetized accessory chrome spinel. Being ferromagnetic, the ultrabasic rocks have a magnetic susceptibility, which varies also in broad limits. Apart from this, being ferromagnetic these rocks might have a large natural remanent magnetization (I_r). In this way the ultrabasic rocks can be considered from partially unmagnetic to strong magnetic.

The fresh dunites and hartzburgites of tectonic sequence are not magnetic and cannot be distinguished by their magnetization if their degree of serpentinization is equal (Fig. 4-26, table 4.5). The magnetic properties of these two kinds of rocks vary within almost the same limits. Remanent and induced magnetization have respective values 10 x 10^{-5} units SI and 40 x 10^{-5} unit SI, so $Q_n<1$, in the fresh rocks practically unserpentinized and cataclasised. The ration $Q_n=I_r/I_i>1$ is approximately in 48% of the cases, with average value 2,3 for dunites and 1,9 for hartzburgites. That reveals the influence of the thermal nature of the remanent magnetization. With the increasing of the activity of cataclases, magnetism is strengthened, especially the natural remanent magnetization. The fresh rocks have unequal magnetic properties in different regions.

The rocks that contain ferromagnetic minerals, for example secondary magnetite are more magnetic. An induced magnetization (80-130) x10^{-5} units SI can be conditioned by presence of 0,1% of magnetite.

In general, dunites are a bit more magnetic than hartzburgites, that means that they are more serpentinized and contain more secondary magnetite (Fig. 4-31, 4-32, 4-33).

With the increase of the serpentinization process, the magnetization (in particular the remanent magnetization) of dunites and hartzburgites gets stronger. This can be explained by the increase of the secondary magnetite and the thermoremanent magnetization. The magnetism of the serpentinites has a particularly characteristic: Its values vary in a wide range, from practically unmagnetic to strong magnetic, with values of I_r = 70,000·10^{-05} SI units and I_i = 3100·10^{-05} SI units.

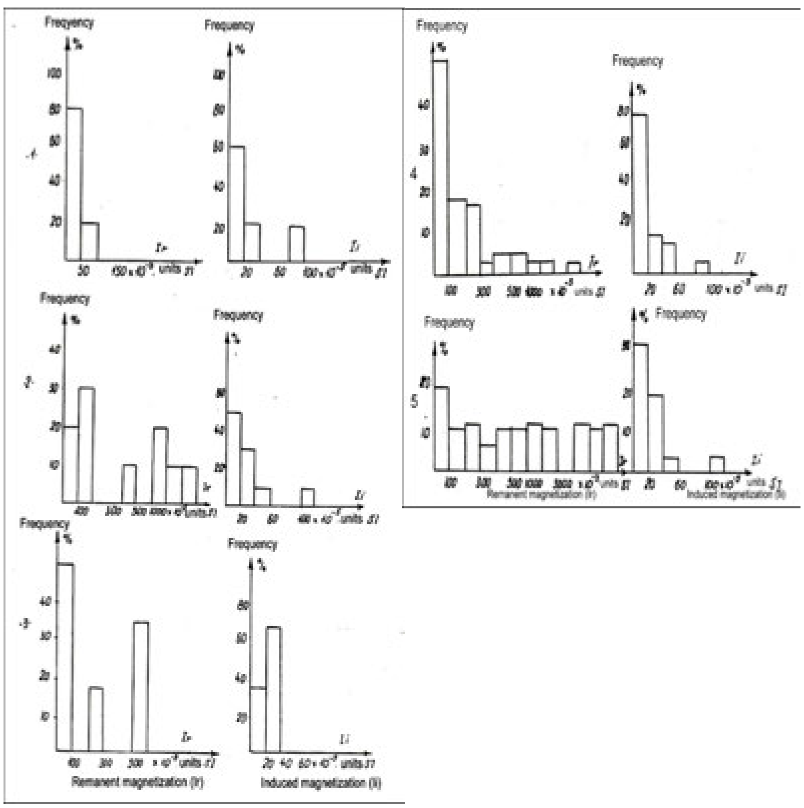


Fig. 4-31. The histograms of the variation of remanent (I_r) and induced (I_i) magnetization of the rocks in Fushe Kalt (Bulqiza) deposit (Plotted by data Sharra Xh. Et al. 1987, accorded to the measurements of Kosho P., Dema Sh., Rrënja A.).

1. Average serpentinized dunites; 2. Strongly serpentinized dunites; 3. Little serpentinized hartzburgites; 4. Average serpentinized hartzburgites; 5. Strongly serpentinized hartzburgites.

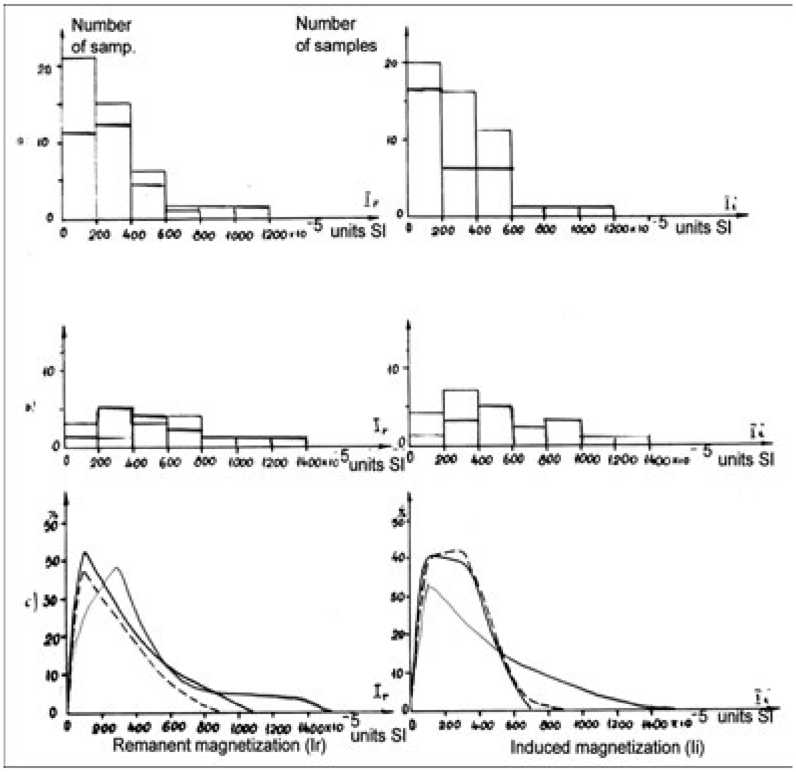


Fig. 4-32. The histograms of the variation of remanent (I_r) and induced (I_i) magnetization of the rocks in Kami (a), Vlahna (b) and variation curves (c)(Frashëri A., 1974).
1. Serpentinites from dunites (55 samples); 2. Serpentinites from hartzburgites (59 samples); 3. Piroxenites (102 samples).

This phenomenon can be explained by the degree of serpentinization because the quantity of serpentines in the rocks doest not always determines the quality of secondary magnetite (Photo 4-7, 4-8, 4-9, 4-10). For example there is met serpentinites from hartzburgites totally serpentinized and transformed into serpentine and less in carbonate, which does not contain secondary magnetite and has I_i=80x10^{-5} units SI, I_r=200x10^{-5} units SI.

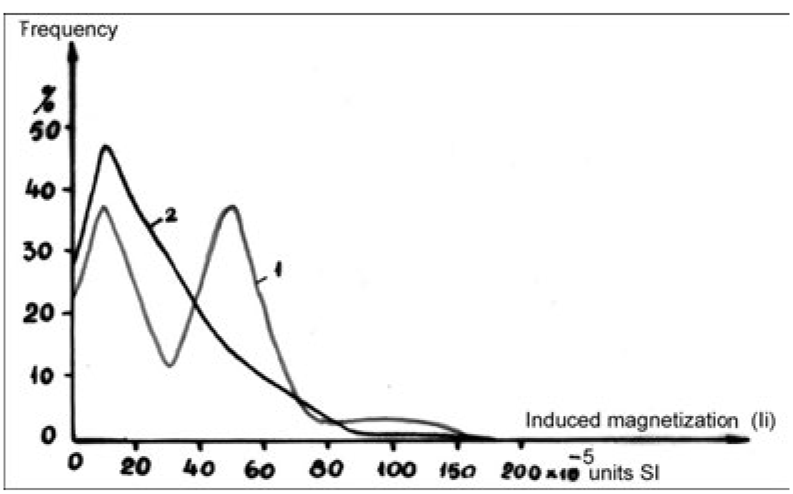


Fig. 4-33. The variation curves of induced (I_i) magnetization of the dunites (1) and hartzburgites (2), Ragami deposit. (Frashëri A., 1974).

These great changes of the remanent magnetization, induced magnetization and of the Q_n ratio for chrome spinel ores, ultrabasic rocks, in general, and for the serpentinites in particular, is conditioned, not only by the contain of the secondary magnetite. These phenomena are conditioned by the chemical and mineralogical transformations of the rocks during the serpentinization and by the redistribution of mechanical stresses, as well. The effect of dislocations is observed under the action of mechanical stresses during the process of the serpentinization, of the dynamometamorphism and of the tectonic activity. For example, in Cerruja deposit, the dunites and hartzburgites of the tectonic sequence are serpentinized. The serpentine contain, in some cases, reaches from 50% up to 85-90% of the rock's volume.

Different amounts of secondary grains magnetite can be found along the skeleton network directions. Contain of the secondary magnetite in this kind of rocks is 4-5%, while contain of secondary magnetite grains inside the mass of the serpentine of the hartzburgites is 0.1-0.4%. For this reason, the susceptibility of this sequence varies in a wide range. The variation curve of the dunites has two maximums, one at the value of $120 \cdot 10^{-05}$ SI units and the other one at the value of $719 \cdot 10^{-05}$ SI units. This means that there are two kinds of dunites: weak magnetic and magnetic. The magnetism of the cumulate sequence rocks changes in the plane and in the cross-section. There are alternations of nonmagnetic and strongly magnetic rocks.

Vein rocks, like pyroxenites in the majority of the cases are made up to medium granular to coarse-grained enstatite more or less bastitized. The rock is cataclasised and in the jumping and fissures zone there is often observed contain of fine-grained secondary magnetite. The magnetism of pyroxenite varies within wide limits. However, the majority of pyroxenite are weak magnetic. The values of their induced magnetism are ($I_i = 350 \cdot 10^{-05}$ SI units, $I_r = 150 \cdot 10^{-05}$ SI units) (Table 4-5). With the increase of the quantity of the secondary magnetite, the magnetism increases. The ratio Q_n has an average value 4,0, but in particular samples up to 114. In these cases, the remanent magnetization has a thermal nature, under the influence of the magnetic field of the earth and surrounding rocks.

The gabbro-pegmatite are magnetic only in the cases when there is primary magnetite in their composition, like in the cases of cumulate sequence (Tab. 4.5).

Petromagnetic studies have shown the presence of inverse magnetization phenomenon for chrome spinel ores in some deposits (fig. 4.34).

From this picture, it can be seen that the ores in Kepenek deposit (Tropoja ultrabasic massif), are characterised by vectors of remanent magnetization oriented in the average azimuth $\Phi=356°$ and with dipping angle $\theta=-70°$, i.e. opposite to the

direction of the vector of remanent magnetization for surrounding rocks. The surrounding dunites the dipping angles of the I_r vector is averagely $\theta=60^0$, where as the azimuth $\Phi=42^0$.

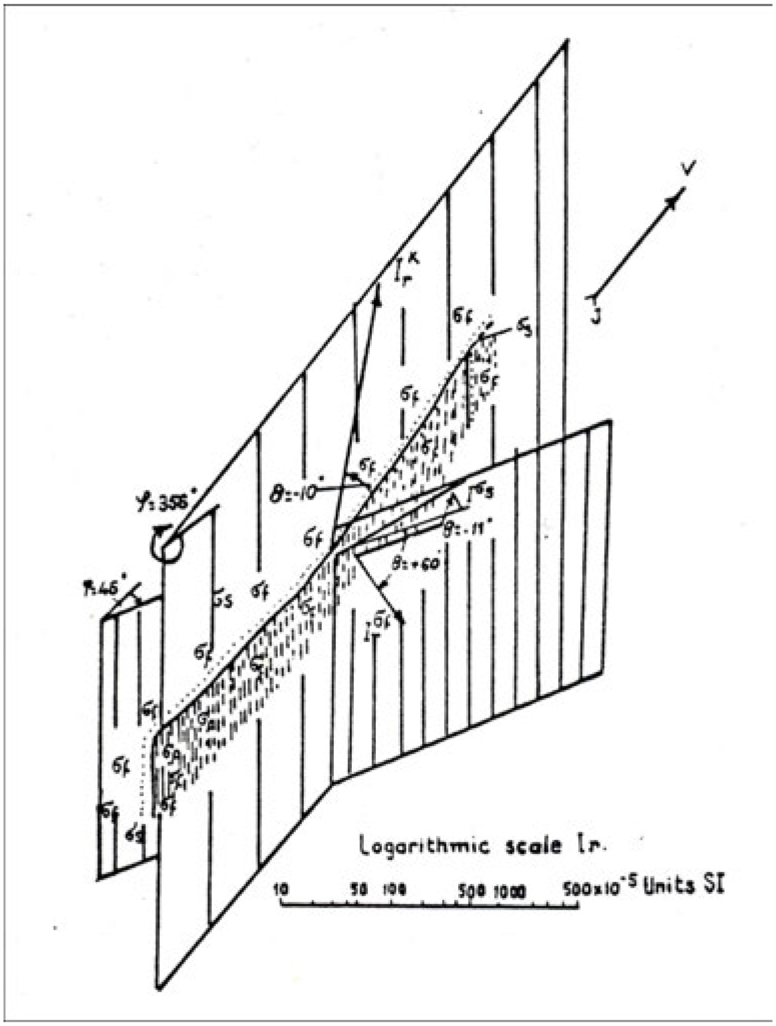


Fig. 4.34. The inverse remanent magnetization (I_r) for a chrome ore in Kepenek deposit, Tropoja ultrabasic massif. (Frashëri A. 1974, 1989).

The sample from the dunitic envilope with I_r vector, preserving the azimuth of direction $\Phi=46^0$ (as in the rocks that are far from the ore body), has a negative inclination angle, as in ore $\theta=-11^0$. The petrographic study of the orientated thin sections show that along the direction with azimuth of about 45^0, is noticed an event more accentuated development of the action of cataclisis of the rocks, which is expressed by a great number of cracks and microfissures. The majority of the microfissures, especially the most developed, are filled with serpentine of the chrysotile and microantigorite types and with some chrysotile-asbestos vein. There is found secondary magnetite concentrated in microfissures, especially in their periphery. Along the direction 45^0, some prolonged crystals of olivine are noticed in a lying position so the direction of the vector I_r agrees with the direction of the elements with primary structure (Photo 4.11).

The direction of I_r vector of the chrome-spinel coincides with the strike of the ore body. The negative direction of the inclination of the ore's remanent magnetization vector may be explained by the self inversion inside the spinel; or as a consequence of the demagnetization action of the magnetic field of the surrounding rocks (when the ore body was created after the process of the crystallization of surrounding rocks). These rocks were already magnetized and the ore was magnetized under the action of the demagnetising field of the surrounding rocks (Fig. 4.35). Under the thermal influence of the ore matter, in the dunitic envelope of the ore body the direction of the I_r inclination has changed.

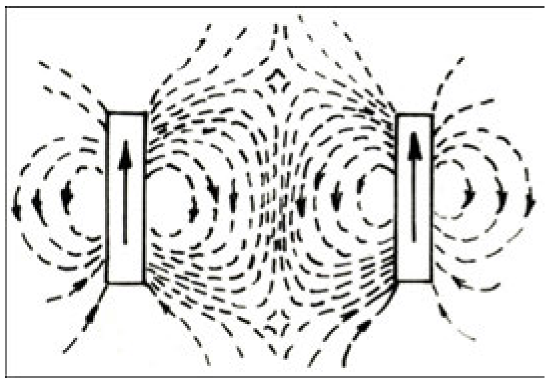


Fig. 4.35. Distribution of magnetic lines in the space between two bodies near each other, with the magnetization vectors in the same direction and sense.

There are some geological facts that are in the favour of this idea: Among the ultrabasic rocks there is also met chrome spinel ore, with a surface surrounded by 2-3 mm dunite salbande, yellow colour unlike the for dunites, which are more or less green (Photo 4-12). The microscopic study of the polished section has shown that chromite intercalates in the olivine and the part near of the contact is more serpentinized than the other part. This phenomenon shows the thermal influence of chrome spinel on the surrounding olivine. Apart this phenomenon there is also met ore that has cemented regular pieces of olivine (Photo 4-13). The mineralographic study showed that the order of the formation of the minerals is olivine-

chrome spinel ore. Olivine has been recrystalized before the chrome spinel ore. There are also noticed intercalations of the chrome spinel veilets in small dimensions in the olivine mass. Many other scholars have reached also the same conclusion on the relative later formation of chromite spinel ore and have proved this thesis in many publications (Çina A. et al. 1966, Çina A. 1970, Dede S. 1965).

The reversal of the remanent magnetization vector has been also noticed in some other deposits, such as in Kam (Tropoja), Fushë-Kalt (Bulqia) etc.

In cumulate sequence and the surrounding dunite and hartzburgite rocks (for example in Cërruja deposit, Bulqizë) have observed a normal vector of remanent

magnetization. This vector has a downward direction and a dip angle of 40°. This shows that the ore bodies have been created at the same time with the cumulate sequence of the rocks.

Petromagnetic studies carried out for chromites and ultramaphics rocks demonstrated that:

- Massive structure ores of many deposits are more magnetic than the surrounding rocks.
- Disseminates structure ores are more magnetic than the surrounding rocks.
- There are some nonmagnetic chrome ores.
- The ultramaphic rocks can be distinguished from the surrounding rocks and from each other by their magnetism only if they have different degrees of serpentinization. Fresh rocks are not magnetic. The magnetism of serpentinites changes within wide limits. They are usually magnetic and sometimes strongly magnetic. Non-magnetic serpentinites can also be found. The dunites of cumulate sequence are more magnetic than the other rocks.
- In some deposits and occurrences is observed inversed vector of magnetization. In these cases, the negative magnetic anomalies can observe over the magnetic chrome spinel ores.

Tab. 4.8 presents the values of the contrast of the magnetism between the chrome spinel ores and ultrabasic rocks;

Contrast of the magnetism between chrome spinel ores and surrounding ultrabasic rocks in Tropoja massif (Frashëri A. 1974)

Tab. 4.8

7

Kind of the		Deposit or occu-rrence	Student para-meter (t) after I_r	Difference between the values of the magnetism, in $x10^{-5}$ units SI		
Chromite ore	Surrounding rocks			I_r	I_i	$\|I_r+I_i\|$
Rich ore	Serpentinite	Pac Vlahna	2,5 22,2	1000 2000	0 100	1000 2100
	Dunite	Kepenek	10,0	2300	100	2400
Power up to average contain ore	Serpentinite	Kam Vlahna	5,5 8,3	300 1800	130 140	430 1940

4.2.3. Induced polarization (IP)

Polarizability of the ultrabasic rocks and the chrome spinel ores was determined on samples of regular geometrical shape (parallelepiped) with the dimension 100 x 80 x 50 mm. Measurements were carried out in the time domain. The effect of induced polarization was expressed with the coefficient η, which is given:

$$\eta = \frac{dU_{IP}}{dU_p} \times 100\%$$

where: dU_{IP} – the difference of IP potentials, measured 500 ms after the switch off of the charging pulse.

dU_P – the difference of the charging pulse potentials.

In some characteristic samples were studies the IP decay curve in three windows. The first window with integration from 260-520ms. For such measurements, IP chargeability is expressed in mV/V, and given:

$$M = \frac{V_s}{V_p} \times 1000$$

where: V_p- primary voltage

V_s – IP (secondary) voltage

According to our measurements of same samples with both techniques we found that M/η≈4,5.

The chrome spinel ores and the ultrabasic rocks are characterised by IP coefficient values from 0.2 -60%. They may be from unpolarizable to strongly polarizable (Tab. 4-9).

Coefficient of Induced Polarization (IP) of chrome spinel ores and ultrabasic rocks.(Frashëri A. 1974)

Tab. 4.9

Kind of ores/rocks	The scale of polarization	Number of samples	IP Coefficient, in %		
			Min.	Max.	Average
Rich chromite	Low	14	0,7	3,0	2±0,5
	Average	57	3,0	18,0	13±1,0
	Strong	19	18,0	30,0	25±1,0
Chromite with average contain up to massive	Unpolarizable	18	0,2	2,0	1±0,5
	Average	39	2,0	18,0	6±1,0
Dunites	Unpolarizable And low	18	0,2	2,0	1±0,5
Serpentinite from dunites	Low	26	0,4	6,0	2±1,0
	Average	8	6,0	19,0	12±3,0
	Strong	6	19,0	41,0	32±5,0
Hartzburgites	Unpolarizable	51	0,2	2,0	1±0,3
Serpentinized hartzburgite and serpentinite from hartzburgites	Low	20	0,5	6,0	3±1,0
	Average	23	6,0	19,0	11±2,0
	Strong	34	19,0	51,0	35±4,0
Fresh pyroxenites	Unpolarizable	2	0,1	0,2	
Gabbro-pegmatites	Unpolarizable	2	0,3	1,0	

Chrome spinel ores polarizability

The rich chrome spinel ores has an IP coefficient (η) which varies from 0,7 to 30%. The polarizability is divided into three groups:

- Chrome ores with small IP values (0.7-3%) and a predominant IP value of 2%.
- Chrome ores with average IP values (3-18%) and a predominant IP value of 13%.
- Chrome ores with high IP values (18-60%) and a predominant IP value of 25%.

Ore bodies with high IP values have been found in some deposits (Fig. 4-36). Polarisable ores in Kepenek deposit are situated between fresh rocks.

The chromites of cumulate sequence (for example Cërruja deposit) have IP values from 2% up to 4%. The ores of average and dense dissemination have the highest IP values. This feature is not very high for massive chromites. Low up to medium IP values have been observed in Kami and Vlahna deposit, (Tropoja massif) where chrome ores are situated between serpentinized rocks, and also in Tri Gjepra zone (Bulqiza) (fig. 4.37, 4.38).

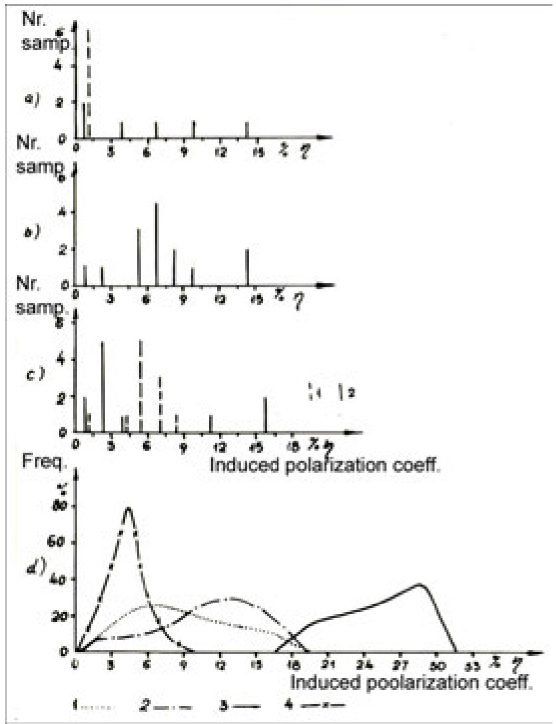


Fig. 4-36. Variation curves and histograms of IP coefficient of chrome spinel ores in Kam deposit (a), Paci occurrence; c) Vlahna deposit; d) Kepenek deposit. (Frashëri A. 1974).

c) 1- Rare up to average disseminates ore; 2- Rich ore.

d) 1- Disseminates ore among the dunites (27 samples); 2- polarizable massive ore among the dunites (39 samples); 3- strongly polarizable ore among dunites (19 samples); 4- ore among the serpentinized rocks (28 samples).

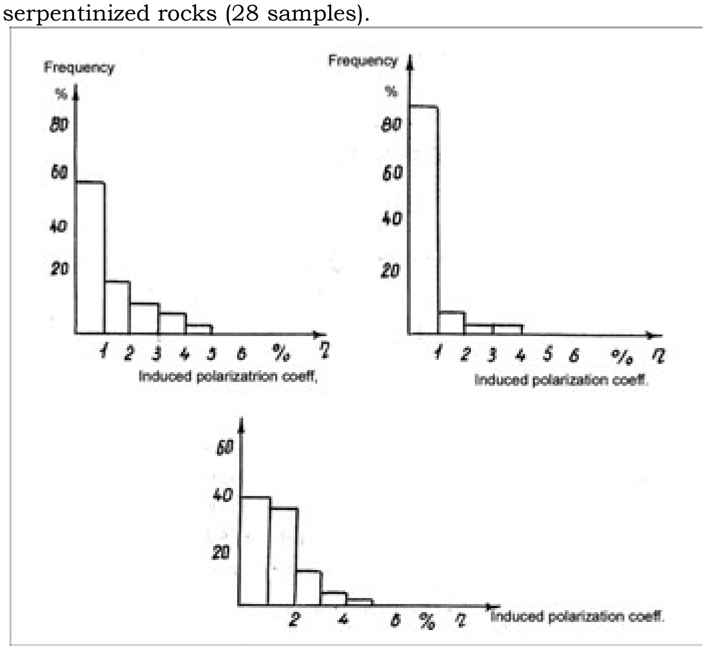


Fig. 4-37. Histograms of the IP coefficient variation in Tri Gjepra zone (Bulqiza massif), (plotted according to data presented by Prenga Ll. et al. 1986).

1. Chromites; 2. Dunites; 3. Hartzburgites.

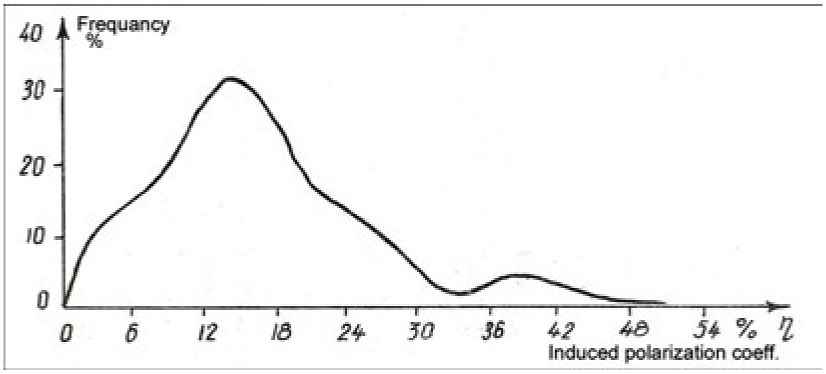


Fig. 4-38. The variation curves of the IP coefficient of the chrome ores in Cërruja deposit (Bulqiza massif).

In some deposits of average and high grade chromites except for chromite with average contain and sometimes rich chromites with average IP values, unpolarized ores exist as well (0.2 - 2%).

Fig. 4-39 present variation curves of IP coefficient for chrome ores of deposits in the Tropoja massif.

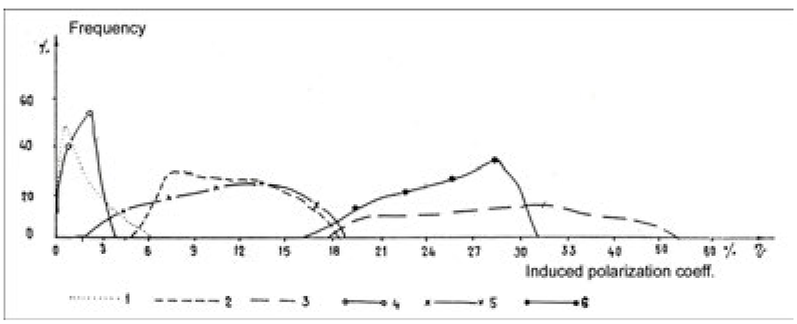


Fig. 4-39. The variation curves of the IP coefficient for the chrome ores and ultramaphics rocks of the Tropoja massif. (Frashëri A. 1974).

1. Unpolarizable average contain and poor ores (7 samples); 2- Polarizable average contain and poor ores (39 samples); 3- Unpolarizable rich ore (14 samples); 4- Polarizable rich ore (57 samples); 5- Strongly polarizable rich ore (19 samples); 6- Weak polarizable ultrabasic rocks (115 samples); 7- Polarizable ultrabasic rocks (31 samples); 8- Strongly polarizable ultrabasic rocks (40 samples).

The study of the polarization of massive chrome ores, in the majority cases, shows that high grade of IP polarization ores have higher levels of polarization than those with rare up to average disseminates.

As can be seen from the IP coefficient variation curves (figs. 4-36 up to 4-39), the ability of chromites to get polarised is not the same, not only for different deposits but even for particular ore bodies of the same deposit and in side of the same ore body as well.

Polarizability of the ultrabasic rocks

The IP coefficient of cumulate sequence ultramaphic rocks varies in a wide range than in the chromites (fig. 4-40). If the maximal value of this IP coefficient reaches in 30% for the chromites, in the investigated rocks this one reaches up to 51% (Table 4-8).

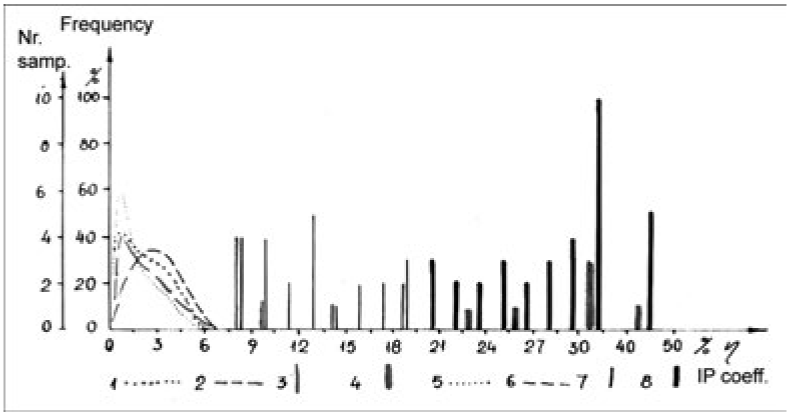


Fig. 4-40. Histograms and variation curves of the induced polarizability. Of ultrabasic rocks. (Frashëri A. 1974).
1- Dunites; 2- Weakly polarizable serpentinites from dunites; 3- Polarizable serpentinites from dunites; 4- Strongly serpentinites from dunites; 5- Hartzburgites; 6- Weakly serpentinites from hartzburgites and serpentinized hartzburgites;
7- Polarizable serpentinites from hartzburgites and serpentinized hartzburgites; 8- Strongly polarizable serpentinites from hartzburgites and serpentinized hartzburgites.

The secondary magnetite, in the cumulative sequence dunite, is present in the form of veinlets. The magnetite is higher especially where there is chrysotile-asbestos banding. The distribution curve of the IP coefficient of dunites has two maximums in Cerruja deposit. This indicates the presence of nonpolarisable dunites and strongly polarizable ones (fig. 4-41). The polarization values of the Cërruja deposit hartzburgites, vary in wider range than the chromites and dunites. Their IP coefficient varies from 0.2-51% and only one maximum point with a coefficient value of 3.2 % can be observed.

Strong polarisability is characteristic for magnetic dunite and hartzburgite. The IP polarization of cumulate sequence rocks changes not only in horizontal plane but also in vertical section. Alternations of nonpolarisable rocks with strongly polarisable ones can be observed.

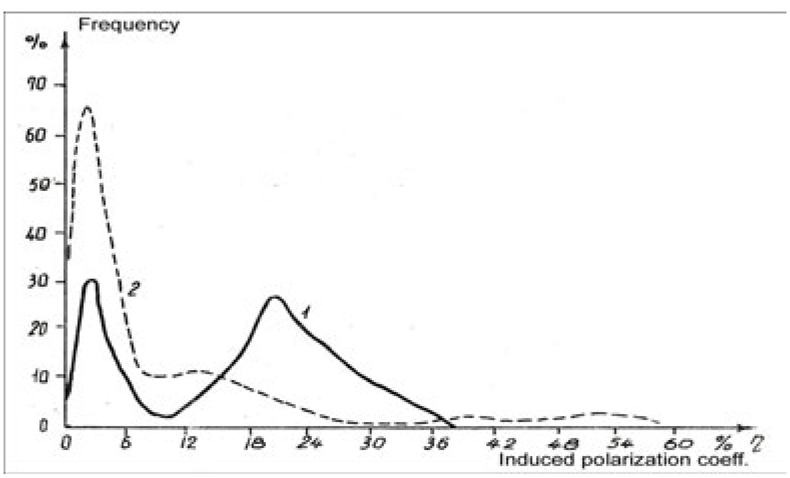


Fig. 4-41. The variation curves of the IP coefficient of the Cërruja deposit, Bulqiza ultramaphic rocks. (Frashëri A. 1974)
1 - Dunite, 2 - Hartzburgite.

Based on the level of polarizability, rocks can be classified as low, average and strong polarisable ones.

The dunites, hartzburgites and a kind of serpentinites can be considered as rocks with low polarization. Their predominant IP coefficient value is about 1%.

The polarisability of the ultramaphic rocks increases with the increase of the serpentinization. According to the petrophysical studies, the polarization of chrome ores and ultramaphic rocks is mainly determined by contain and the shape of the secondary magnetite and in some cases by the small disseminates of the pentlandite, when they are present. Greater effect can be observed in cases when the secondary magnetite is present in the shapes of fine chains, very thin veinlets or lattice (Photo 4-14 and 4-15). There are many rocks with strong polarization more than the chrome spinel ore. No difference noticed between the serpentinites from dunites and serpentinites from hartzburgites.

In order to know the nature of so changeable and strong polarizability of chrome spinel ores and the ultrabasic rocks we have studied the relation of the IP coefficient to the induced magnetization, electrical resistivity, the contain of the minerals with electronic conductivity or as semiconductors, the humidity and to the technical survey parameters like the density of the polarizing current and the time of charging pulse. The form of the decay curve of the IP effect was also studied.

For other equal conditions (resistivity, rock soakness and the technical survey parameters) there exists the linear relation between the IP coefficient and the induced magnitization, for the ores and the ultrabasic rocks, too (fig. 4-42, 4-43). The relations with greater slope are those of the strongly polarized rich chromites, and of serpentinites. Since the induced magnetization of chrome spinel ores and the ultrabasic rocks depends on the presence of the secondary magnetite within, the induced polarizibility of the chrome spinel ore and the ultrabasic rock as well is determined by the contain of this semiconducting mineral that can be strongly polarized. These conclusions were fairly well proved by petrographic and mineralogical studies.

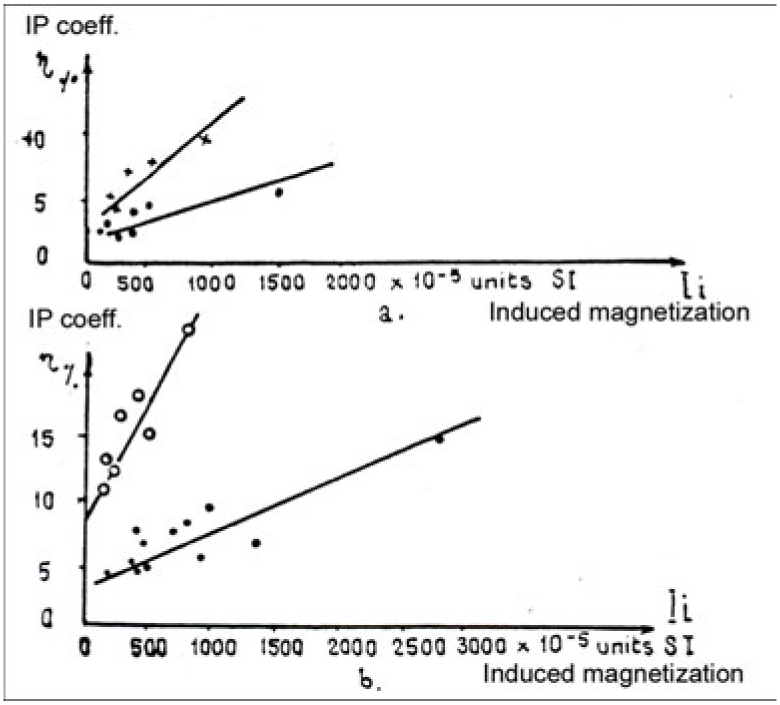


Fig. 4-42. The dependence of the IP coefficient by induced magnetization (I_i) for the ore with average disseminates (a) and rich ore (b). (Frashëri A. 1974, 1989).

1- Polarizable rich ores and disseminates ores;
2- Average disseminates ores; 3- Strongly polarizable massive chromites (resistivity about 20 000 Ohmm).

The ore cannot be polarized does not contain secondary magnetite. The ore has a polarizability up to 4% when it has small quantities of secondary magnetite in the form of detached spots. The polarizability is increased many times, not only when the quality of magnetite is increased but also when it is placed very thin chains and veinlets (their thickness may be 0,00064-0,0032 mm). The polarizability assumes values over 20% in the cases when the secondary magnetite is in a net-structure in the massive ore. The presence of other minerals with electronic conductivity or semiconductivity such as petlandit, have influences on the polarizability. It is very often found, though in small quantities, in chrome spinel ores in the form of very fine-grains crystalline individuals.

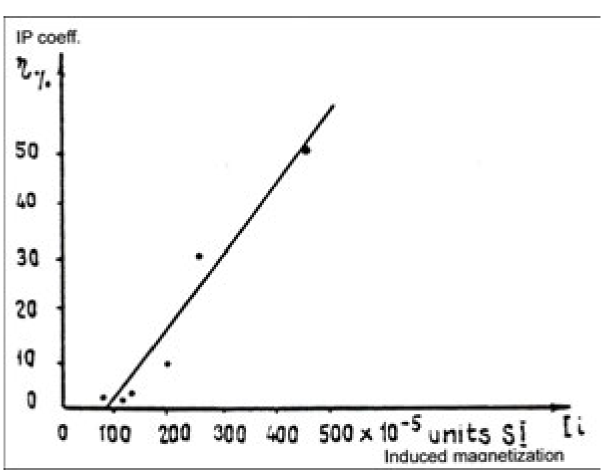


Fig. 4-43. The dependence of the IP coefficient by induced magnetization (I_i) of the serpentinites (resistivity about 50 000 Ohmm).(Frashëri A. 1974, 1979).

The fresh and the serpentinized rocks that do not contain secondary magnetite practically are not polarized (η<0,2%). With the increase of the quantity of magnetite the IP coefficient is also increased. Where the secondary magnetite is the form of the fine chains and veinlets, the coefficient of IP has maximal values.

In this way it is proved that the induced polarizability of the chrome spinel ore and the ultrabasic rocks first of all depend from the quantity of the secondary magnetite and the other minerals with electronic conductivity, as well as on the geometric of the grains of these minerals and the manner of their placing in the ore or in the rock.

There are also defined the dependence of polarizability on the resistivity of the ore and the ultrabasic rock (fig. 4-44). With the increase of the resisivity, polarizability is increased and reaches the maximal values in the samples with a resistivity of 100 000 Ohmm. With the further increase of resistivity, the polarizability begins to decrease.

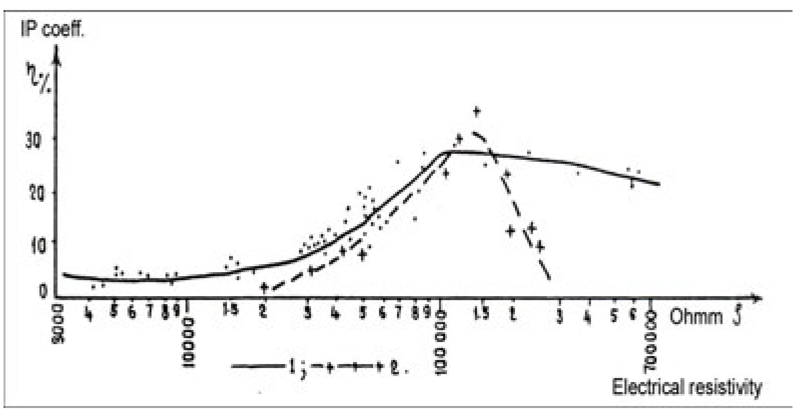


Fig. 4-44. The variation of the IP coefficient on the resistivity of the chrome ore (I_i=500.10^{-05} SI units) (1) and on the resistivity of the tectonic sequence serpentinite (I_i = 150 10^5 units SI) (2). (Frashëri A. 1974, 1989.

We have studied the relationship between IP coefficient and humidity, in order to better know the dependence of polarization on resistivity. Both these dependences (the dependence of the induced polarizability by resistivity and by the rock soakness) show that the IP effect depends from the level of saturation with

water in the porous space of the ore or rock. When rock soakness is decreased to a certain level, the majority of the general polarizing current flows through the pores, which are blocked by the grains of magnetite, so the effect of IP become greater. The quantity of the IP effect greatly decreases for very small quantities of water. This reduction happens because, the surface of magnetite grains has a smaller affinity for water than the surface of the other neighbouring silicate grains for small contains of water, so the surface of the magnetite is the first to be dried. The same happens with the dependence of the IP effect on the resistivity. With the increase of resistivity to a certain limit, in analysed case equal to 100000 Ohmm, the part of the current that flow in the empty pores is reduced and the density of the polarizing current that penetrates into the magnetite grains is increased, the effect of IP is strengthened. The reduction of the IP effect for the samples with an extraordinarily large resistivity, over 100000 Ohmm, is connected with the general reduction of the density of the current that the flow through the sample, particularly through the magnetite grains.

This regularity is not observed everywhere. An example of this are the ores located in the cumulate sequence of the Cërruja chrome deposit (Bulqiza massif). For this ores it has been observed that with the increase of resistivity the IP coefficient decreases.

The amplitude of the induced polarization also depends on the density of the polarizing current (Fig. 4-45). For the averagely polarized ore, the IP potential varies linearly only in the initial interval, for a density of the polarizing current of 0,015-0,15 μA/cm². The ore that is weakly polarized retains the linearity of the variance of the potentials of IP from the density of the polarizing current for many times greater values (up to 6,5 μA/cm²). This shows that this kind of ore is polarized as the environment with ionic conductivity.

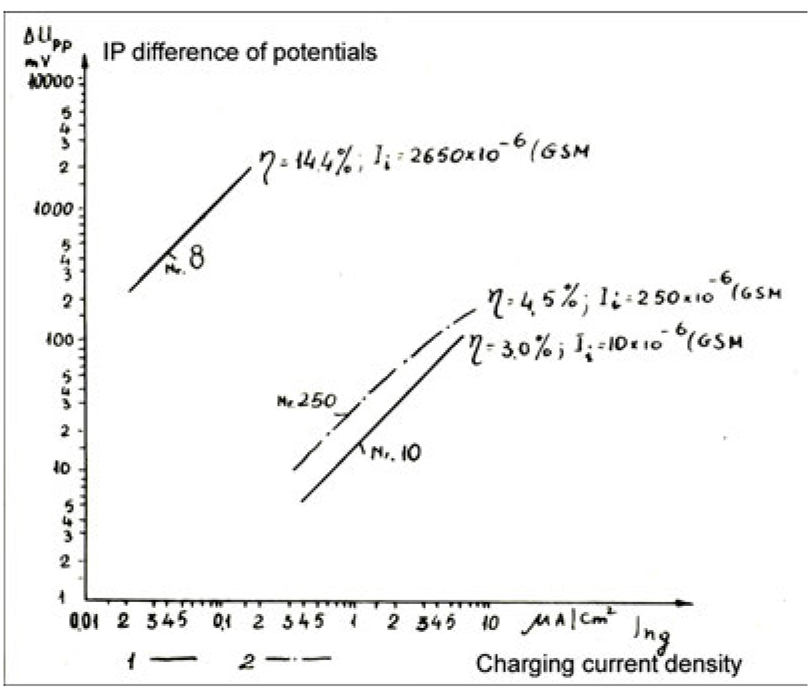


Fig. 4-45 IP potential (U_{pp}) dependence by the polarizing current density (j_{po1}). (Frashëri A. 1974).

1 – Chrome spinel ore; 2) Dunite.

In dunites, linearity is destroyed after the density of 3 μA/cm^2 of the polarizing current. The curve of the rocks, which have a magnetite in the form of thin veinlets placed in a lattice shape, is different from the one where the magnetite is present as homogeneously distributed dust. In the first case, the IP potential changes are linear up to the point where the density of polarised current reaches the value of 6 μA/cm^2. The curve is characteristic for the metal-electrolytic interface. Therefore those rocks are strongly polarisable (the IP coefficient is 22.3%). Some of serpentinites cannot get a polarizibility (IP coefficient is 1.8%) because their magnetite is distributed like dust. In this case we have to do with a straight line, characteristic for the polarization of the ionic conductivity rocks, which is smaller than that of the metallic-electrolytic interface.

The above-mentioned factors, related with nature of polarization, find reflection even in the charge and decay curves of the later phase of IP effect (Fig. 4-46). The more prolonged charge and decay curve is found in the ores that the strongly polarized. In these ores the decay of the IP effect continues as long as the charge. About 50% of the potential of IP decay is observed averagely 20 seconds after the switching off of the polarizing current. In the ores and dunites that are weakly polarized, the decay of the effect of IP is almost three times quicker than in the above-mentioned case. The quantity of the potentials of IP is reduced 50% after 12 seconds for the ore and 8 seconds for dunites, since the moment of switching off of the polarizing current.

A short decay like this is characteristic for the polarizability of the environment with ionic conductivity. Analysing all the data related with the nature of the polarizability of the chrome spinel ore and the ultrabsic rocks, we reach the conclusion that their average and strong polarization is a voluminous polarization developed in the metal (magnetite)-electrolyte interface. The absence of distinctions between the anodic and cathodic polarization speaks of the volume's nature of polarization, too.

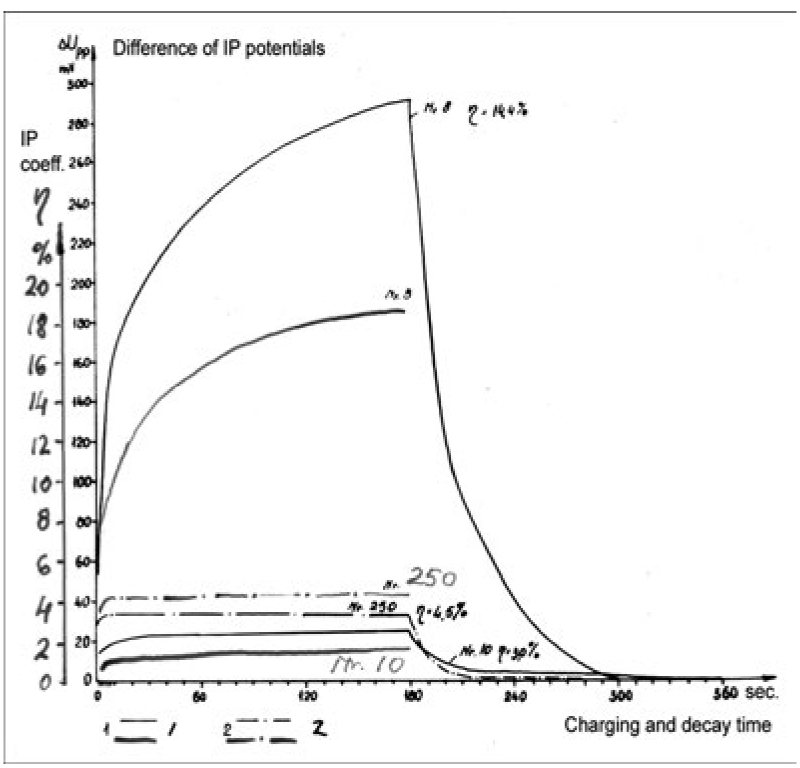


Fig. 4-46. The charging and decay IP curves of the chrome spinel ore (1; 2) and dunites (3; 4). (Frashëri A. 1974).

Beside the facts mentioned above, another phenomenon has been observed in some kinds of ores (for example, in Cërruja deposit). In some zones has been found chromite without secondary magnetite which can be polarized up to 20%, and chromite with less than 0.2% of secondary magnetite in dust form, with an IP coefficient up to 40.6%. These kind of polarisable ores are different from the nonpolarizable ones (IP coefficient is 2%) only by contain and homogeneous distribution of the chrome spinel aggregates inside the serpentine mass. These last ones have less chrome-spinel (35-40%) and can get polarized more than the massive ores.

From the correlation of the IP coefficient with the density, can be understood that the polarization is increased with the decrease of the density. This phenomenon shows that the IP of the ores is affected by the ore structure, the serpentinization degree of the olivine, the development of its capillary system and by contain of the metallic mineral.

For the tectonic sequence rocks with the same contain of metallic grains, it has been observed that, the rocks of low porosity are more polarisable than the ones of greater porosity. This means that the IP effect is connected with the rock's structure, and especially with its compaction and with contain and the form of the metallic grains.

Residual polarizabilities of the chrome spinel ores and ultrabasic rock in Tropoja massif are presented in the tab. 4-10.

The polarization study of the chrome ores and the ultrabasic rocks shows that :

1. Strongly polarisable rich chrome ores, can clearly be distinguished from the dunite, hartzburgite and serpentinite with low and average polarisability.

2. Rich and poor ores of average polarisability can be distinguished from the fresh ultramaphic rocks of low polarisability.

3. Serpentinized rocks and serpentinite with secondary magnetite are strongly polarisable and can be clearly distinguished from the fresh ultramafic rocks.

Residual polarizabilities of the chrome spinel ores and ultrabasic rock in Tropoja massif
(Frashëri A. 1974)

Tab. 4-10

Kind of ores and rocks	Surrounding rocks	Student parame-ter (t)	Residual IP coeff. in %
Strong polarizale rich chromite	Dunite, hartzburgite	8,8	24
	Average polarizable rocks	3,9	14
Average polarizable rich chromite	Weak polarizable rock	3,9	11
Averagely polarizable of chromite with average contain	Weak polarizable rock	6,7	5
Stron polarizable seprpentione	Weak polarizable rock	12,9	30
Averagely polarizable serpentine	Weak polarizable rock	4,2	9

Based on petrophysical properties of the ultramaphic rocks and chrome ores it was concluded:

1. The density is a more stable and typical physical property, which can be used for distinguishing chromites from the surrounding rocks. Therefore the gravity method is the basic geophysical method for the search for chrome deposits.
2. The gravity, as the main geophysical method of the search, can not substituted by magnetic surveying and either of them can not be substitute geoelectrical methods (as IP). There are strongly polarisable or magnetic ores whose density values have very small differences or no differences from the surrounding rocks. The bodies created by these ores, especially when they are situated between fresh rocks, are objects for the magnetic and geoelectrical surveying.
3. There are chrome ores, which have the same or similar features with the surrounding rocks. These ore bodies cannot create local anomalies of physical fields and cannot be studied by geophysical methods. For example the disseminated structure ores, which have an average density value of 3300 kg/m^3 and 32% of Cr_2O_3 contain, cannot be discriminated from the fresh dunite of the same density value.
4. The physical properties of the ultramaphic rocks vary within broad limits and only in some cases a group of rocks can be differentiated by its physical

properties from the surrounding rocks. The cumulate and the tectonic sequences are discriminated. These groups of rocks can create geophysical anomalies comparable with the ore body anomalies.

5. The study of the orientation of the remanent magnetization vector of the ores and the surrounding rocks can be used as a supplementary information source about their formation conditions and consecutive changes in time.

4.3. APPLICATION OF GEOPHYSICAL ME-THODS IN SEARCH FOR CHROME DEPOSITS

Many geophysical studies carried out in the ultrabasic massifs of Albania (as in Bulqiza, Tropoja, Kukësi, Shebeniku, Pogradeci etc) for the search for chrome deposits, which have been successful in many cases. They demonstrated that the geophysical methods are a part of the integrated methods for the search for this mineral ore. A long list of many scientific publications, on this item, is presented in the references.

4.3.1. Exploration for chrome ore bodies

The main principle for the application of the geophysical methods for the search for chrome ores, has been to start with the mapping in well known zones of the mineralization and to extend this mapping further to unknown zones, on surface and in the depth.

The works carried out only in Bulqiza ultrabasic massif can illustrate the effectiveness of the geophysical search for chrome ores. Geological and geophysical mappings, at scale 1:2000 have been conducted in total over 65 km^2 or in 15% of surface of the Bulqiza massif (Ll. Langore tec. 1989). There are observed 215 geophysical anomalies have been fixed. Among them, 191 anomalies have been observed by only of one geophysical method, and 24 ones present complex anomalies: gravity, magnetic or IP. From 64 anomalies, 51 anomalies were fixed over the known chromite bodies/occurrences and have contributed for their development in the strike direction. Thirteen anomalies have been discovered buried chromite bodies without surface outcrops, which have been explored by trenches, galleries and drill holes. Thirty-five anomalies have been evaluated as very important for exploration and development works. Based on them the possibility of following their extension was achieved. Hundred fifty-one have been non-mineralised anomalies; but they are caused by particular rocks, tectonic faults, and topographic effects or by the change of the thickness of the deluvion.

Based on these integrated geological-geophysical studies, industrially useful bodies (or deposits) were discovered in Ternovë, Liqeni i Sopeve, 10 Korriku, Lugu i Gjatë, Jugu i Batrës (M-5 anomaly), Qafë Lame etc. Important results were achieved in other zones such as in Liqeni i Dhive, Maja e Thekrës, Kaptinë , 80 Vjetori, Tri Gjepra, Bishti i Kalit etc.

The efficiency of geophysics is still relatively low in comparison with copper deposit exploration. By integrated geological-geophysical surveys in the 35 objects in the Bulqiza ultrabasic massif to check the anomalies have projected 356 boreholes. From these boreholes, 145 have discovered chromite ores, and 211 have been

negative. The ratio of the success was 1/1,4. Many studies must performed before can be reached proper results for chrome exploration.

a) <u>Ore anomalies</u>

Geophysical anomalies caused by ore bodies have been observed in several areas.

Over the ore bodies, weak gravity anomalies are observed, with amplitude, about 0,1-0,2 mGal (fig. 4-47, 4-48, 4-49, 4-50). These anomalies are more evident after the field transformation (fig. 4-53, 4-55, 4-56).

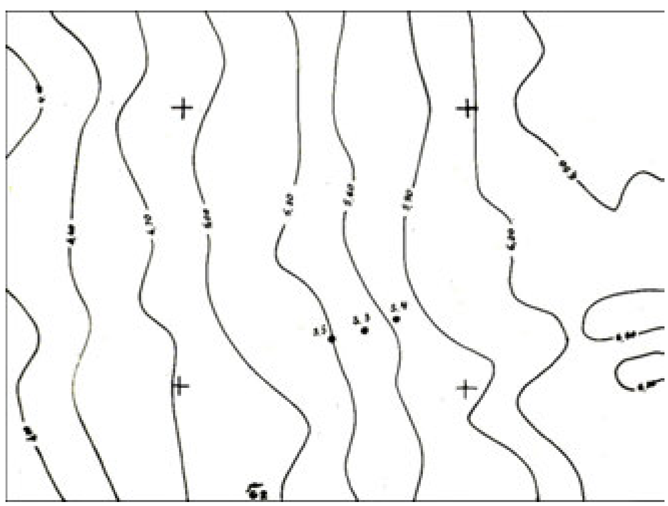


Fig. 4-47. Gravity anomalies map, Bouguer reduction, Kami deposit, and boreholes projected to check residual gravity anomaly. Iso-anomalies every 0,3 mGal. (Mihajllovsky Ja. M. 1960).

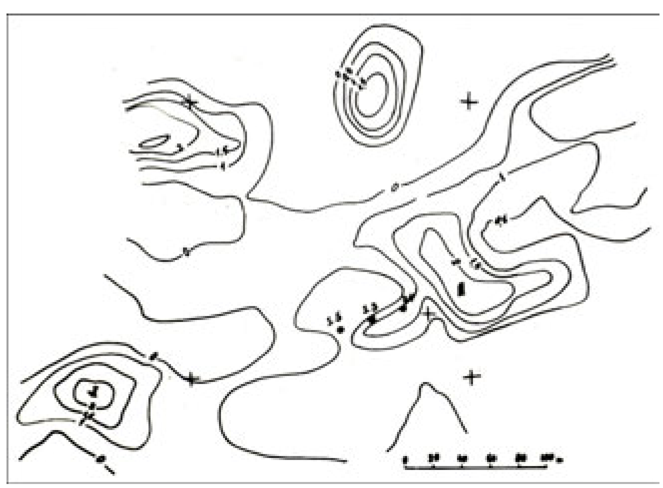


Fig. 4-48. Gravity residual anomalies map, Kami deposit, and boreholes projected to check residual gravity anomaly. Iso-anomalies every 0,5x10-8 mGal/cm. (Lubonja L. et al. 1973).

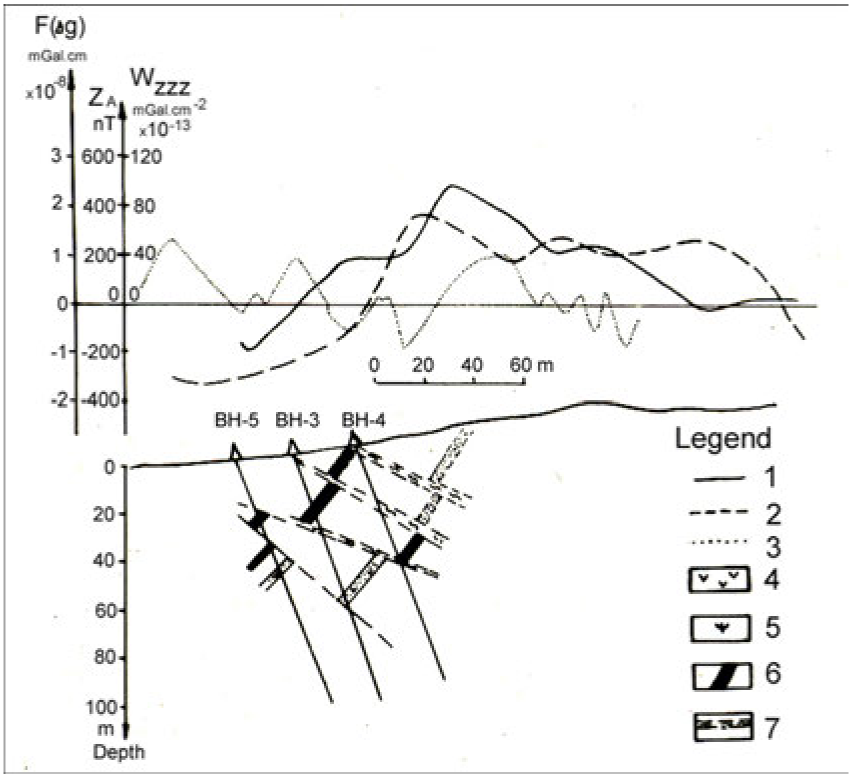


Fig. 4-49. Geological-geophysical section III-III for projecting of the boreholes to check the residual gravity anomaly, Kam deposit. (Lubonja L. et al. 1973).

1- Wzzz profile; 2- F(Δg) profile; 3- ΔZ profile; 4- Dunites; 5- Hartzburgites; 6- chromite ore body discovered by projected boreholes; 7- Disjunctive tectonics.

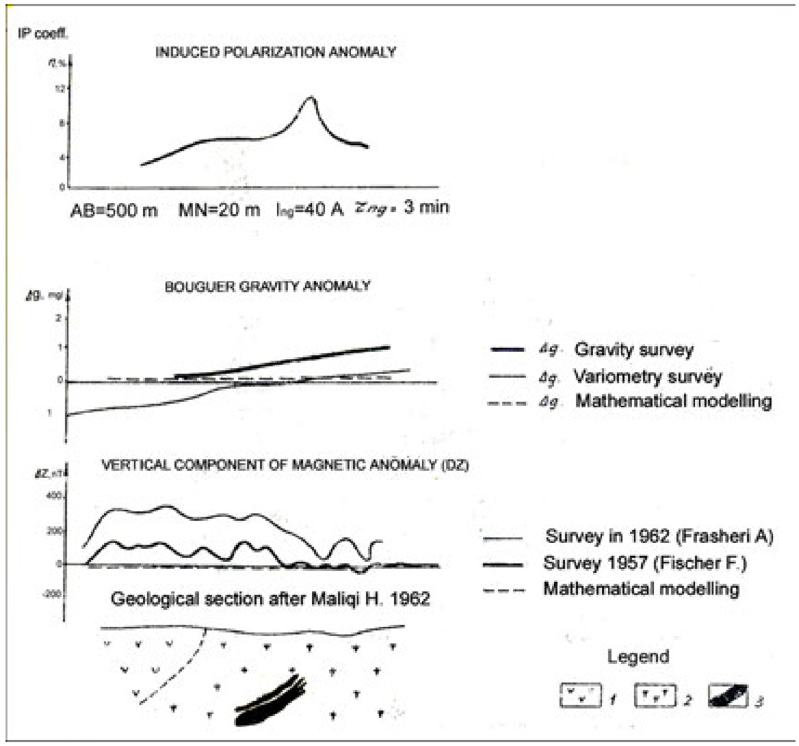


Fig. 4-50. Geological-geophysical section, Kami chromite deposit, Tropoja ultrabasic massif. (Frashëri A. et al. 1971).

1- Peridotites; 2- Dunites; 3- Chrome spinel ore body.

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The gravitational anomaly is expressed in the Bouguer anomaly graph but it is better expressed in the residual gravity anomaly calculated by Saxov-Nygard formula F (Δg) and in the residual local anomaly (Δg) plots. In this cross section, the gravitational and magnetic anomalies were fixed not only on the ore body but also around it (for example in the point 128-142 on particular rocks).

Field transformation of Bouguer gravity anomalies (Δg) in vertical derivatives of second (W_{zz}) and thirty (W_{zzz}) orders of the gravity field potential in the Krasta and Surroi deposits have presented the anomalies with greater amplitudes (fig. 4-9, 4-10).

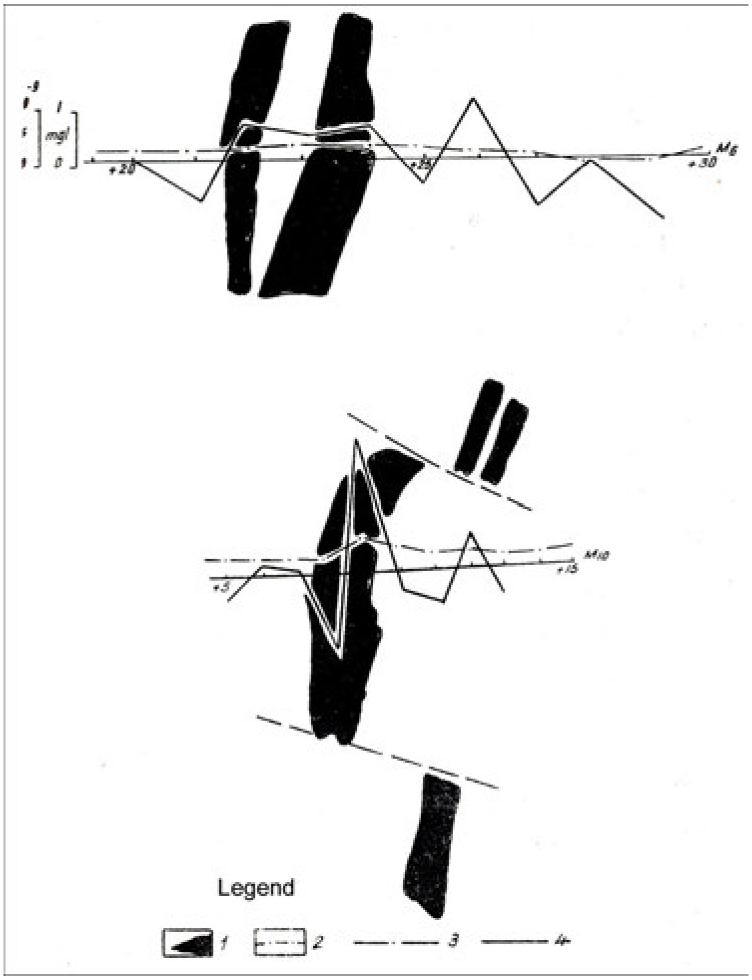

Fig. 4-56. Map of the Bouguer gravity anomalies (Δg) transformation in vertical derivatives of second and thirty orders W_{zzz} of gravity field potential, Surroi deposit, Kukësi ultrabasic massif (Lubonja L. & Frashëri A. 19676).

1- Chromite ore body; 2- disjunctive tectonics; 3- (Δg) profil; 5- W_{zzz} profil.

In the W_{zzz} graphics can detect not only ore bodies, but their apophyses, too. Such transformations are created possibilities not only to amplify weak Bouguer anomalies, but also to select superimposed anomalies over bodies, which are located near each other.

Transformations of the Δg anomalies in vertical gradients of the gravity potential W_{zz} and W_{zzz} must not create the wrong impression that through recalculations is possible to get anomalies even in the cases where there are no Δg anomalies over the chromite body. Transformations and recalculation of the W_{zz} and W_{zzz} only may show up some peculiarities of the Bouguer gravity anomalies map and in the same time diminish and eliminate some peculiarities that don't permit to read the map.

The distribution of the magnetic field in the Kami deposit is turbulent. With great attention have been possible to select the anomalies over the chromite ore

bodies (fig. 4-51). Fig. 4-52. Ore body Nr.6 of the Kami deposit has created very clear IP anomaly (fig. 4-50).

Figs. 4-57 and 4-58 shows the result of the geophysical exploration in the Tërnova deposit in the tectonic sequence, Bulqiza ultrabasic massif.

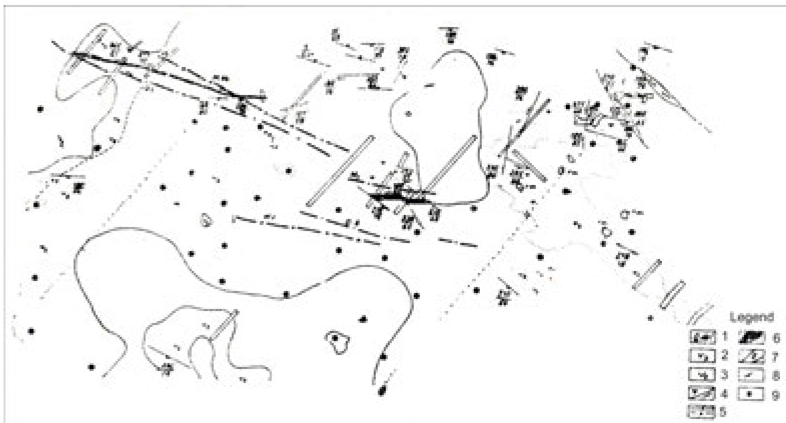

Fig. 4-57. Integrated geological-geophysical map of Tërnova deposit. (Langora Ll. et al. 1989).

1- Overburden; 2- Serpentinized dunites; 3- Serpentinized hartzburgites; 4- Pyroxenite veiny serie; 5- Gravity and magnetic anomalies; 6- Chromite ore body; 7- Serpentinized, schistized and brachiated tectonic zone; 8- Textural elements in the pyroxenite bands; 9-0 Boreholes.

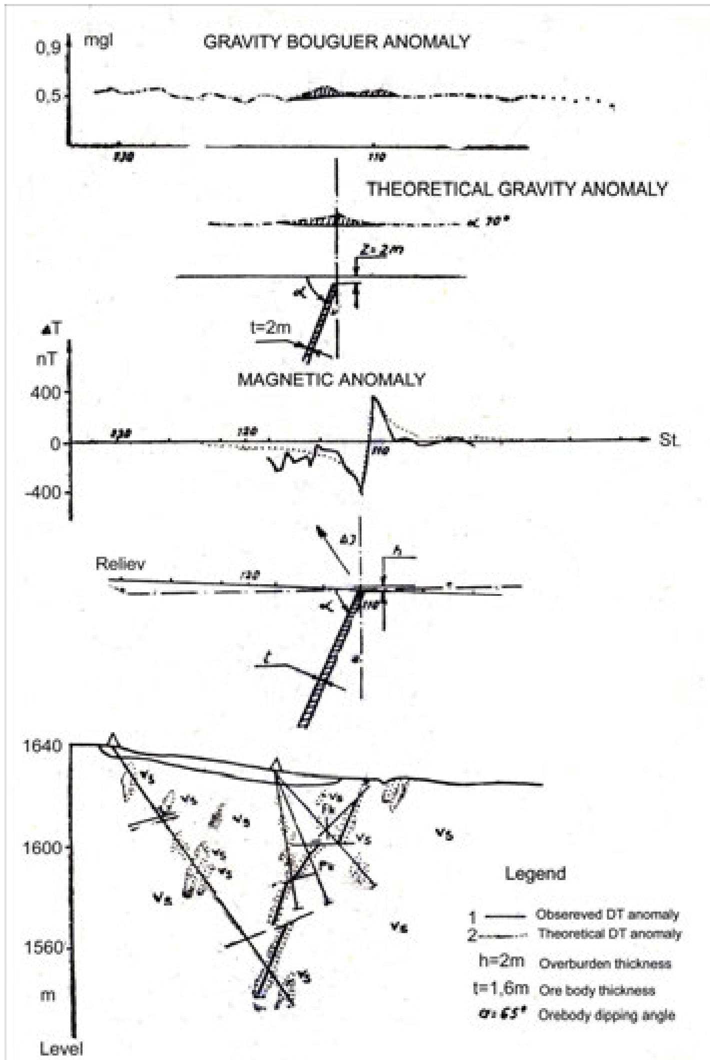

Fig. 4-58. Integrated geological-geophysical section, Tërnova deposit. (Langora Ll. et al. 1989).

1- Observed magnetic anomaly (ΔT); 2- Mathematical modelling magnetic anomaly (ΔT); 3- Overburden thickness h=2 m. ; 4- Ore body thickness t=1,6 m.; 5- Ore body dipping angle, α=65⁰.

In the map, presented in the fig. 4-11, in Tërnova area are outcropped two chrome spinel occurrences. Over the northwestern occurrence were observed complex gravity and magnetic anomalies, with amplitudes respectively 0,15-0,20 Mgal and 400-600 nanoTesla. Over other outcropped body is observed only magnetic anomaly. The fig. 4-58 shows that under the overburden were discovered massive chromite ore body, with thickness about 1,6 m, and 220 m long, which presents the one of ore bodies of the Tërnova deposit.

South Batra area is characterized by absence of chromite mineralization outcrops. In the total intensity of magnetic field (ΔT) there are observed a negative anomaly with amplitude –650 up to –670 nanto Tesla, 320 m long and 80 m width (Fig. 4-59, 4-60, 4-61).

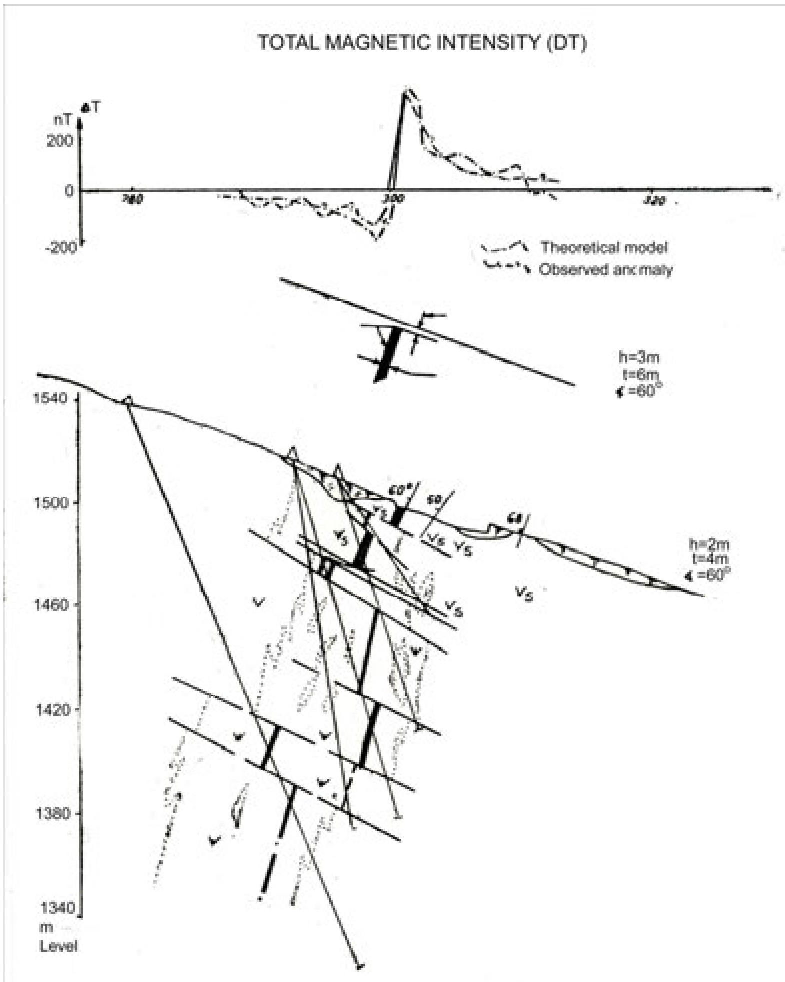

Fig. 4-61. Geological-magnetic section, South Batra area, anomaly M-5. (Langora Ll. et al. 1989).

In the case of the South Batra area, because of inverse remanent magnetization of the chrome ore body, anomaly is very complicated: anomaly presents a negative minimum together with a positive maximum (fig. 4.15). The lowest intensity values for the anomaly were observed where the depth of the ore body was 8 m (fig. 4.61). A horizontal displacement of the extremities of the axis of an anomaly and two maximums were observed in the profile No. 224 (fig. 4.60). This anomalous behaviour can be explained by the existence of a transverse tectonic fault, which divides the body into two parts along its strike. The southern extremity of its northern part and the northern extremity of its southern part are shown in the profile No 224. That means that there were two ore bodies and consequently two maximum points.

As can be seen from the map on figure 4.59, all trenches performed to verify the anomaly, intersected ore bodies, except those presented in the profiles 224, 228. The ore bodies in the profiles No. 224 and 228 were intersected by bore holes in great depths. In the axis of this anomaly 23 bore holes and 3 galleries were

projected at different topographic levels. All bore holes and galleries have intersected the ore body, which runs alongside the anomaly, with a strike about 400 m. The thickness of the body is 2-3 m and its Cr_2O_3 content reached 30-40 %. Dipping ore body has a length of 180 meters.

The search for chrome ore body in the M-5 anomaly, South Batra zone, illustrates the high effectiveness of magnetic surveying.

Intensive and wide magnetic anomalies has been observed over a chromite ore body in the Leshnica and Vlahna deposits, at Kukësi and Tropoja ultrabasic massifs (Fig. 4.62, and 4.63).

The chromite spinel ore of the Leshnica deposit is very magnetic. But, there don't existing IP anomaly. Such absence of the IP anomalies is conditioned by very high

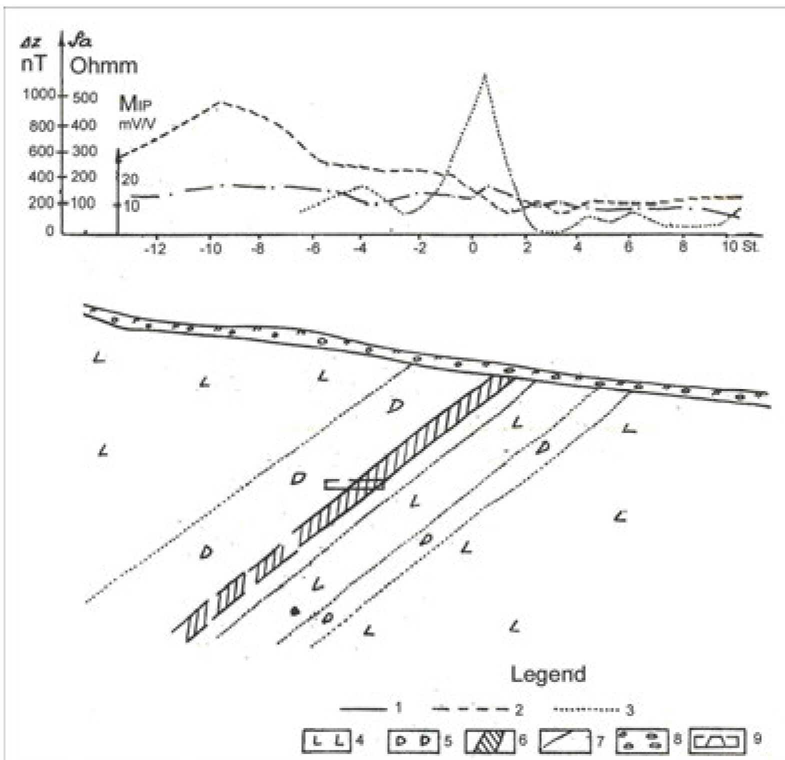

Fig. 4.62. Geological-geophysical section with a positive magnetic anomaly over a chromite ore body, Leshnice area, Kukesi ultrabasic massif (Frashëri A. et al. 1963).

1- IP coefficient profile; 2 - Apparent resistivity profile; 3 - Vertical component (DZ) of magnetic field profile; 4 – Hartzburgites; 5 – Dunites; 6 - Ore body; 7 – Gradual geological boundary; 8 – Deluvion; 9 - Gallery.

humidity of chromites, which are located in the disjunctive tectonic zone, with intensive underground water flow. In such conditions, the magnetic chromite ore is non-polarizable.

Negative magnetic anomaly of the vertical component (ΔZ) of –540 nanoTesla amplitude, and a clear IP anomaly, with amplitude of 35 - 50 mV/V, which is about 3 times over the background level, have been observed over the Vlahna chromite ore body (Tropoja massif) (fig. 4.17).

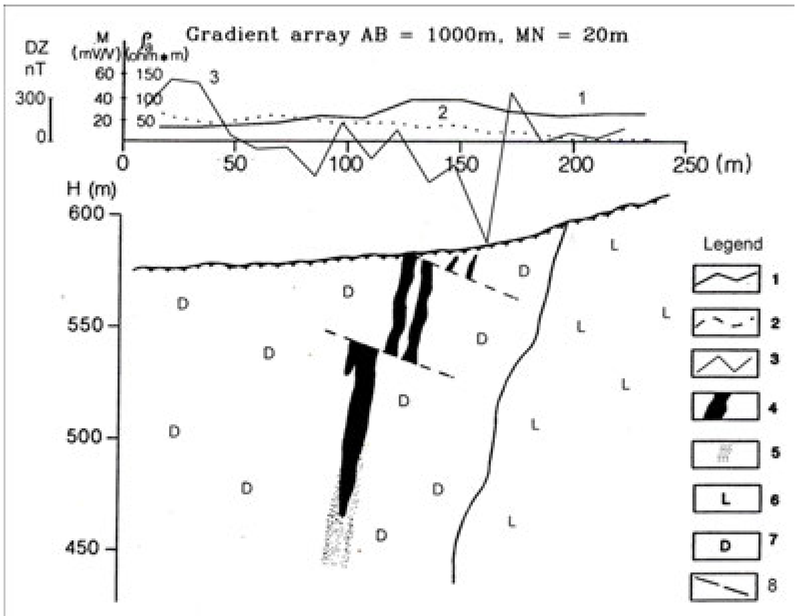

Fig. 4.63. Magnetic and IP anomalies over the Vlahna deposit (Tropoja massif) (Frashëri A. et al. 1963, Lubonja L. & Frashëri A. 1966).
1- IP coefficient profile; 2 - Apparent resistivity profile; 3- Magnetic anomaly (ΔZ); 4 – Masive chromite ore body; 5- Disseminates chromite; 5 – Hartzburgites: 6 – Dunites; 7 - Disjunctive tectonics.

In Tri Gjepra area (Bulqiza ultrabsic massif) has observed IP anomaly (fig. 4.64).

From the IP sections shown in fig. 4-18, can be seen that the IP anomaly is contoured by a line with value of 1.4% over the background level. This level is 1-1.2% for hartzburgites and 1.5-1.8% for dunites. The anomaly has amplitude of 1.5-2.5% at the width of 30-40m. Since the ore body layout is underneath the shallow deluvion, these anomalies can be discriminated better by using of pol dipole array A20M20N,B→∞. Many boreholes and trenches intersected this anomaly, which a length about 280 m.

The chromite ore in the Qafe Gjelas deposit in the Bulqiza massif has a predominant density value of 4000 kg/m^3, which is higher than the density of the surrounding rocks. This is a magnetic ore and has a predominant IP coefficient

value of 1.7%. The dunites and hartzburgites have an IP coefficient of 0.7% and 1.2% respectively. For this reason clear gravitational, magnetic and IP anomalies have been observed over this ore body (fig. 4-656).

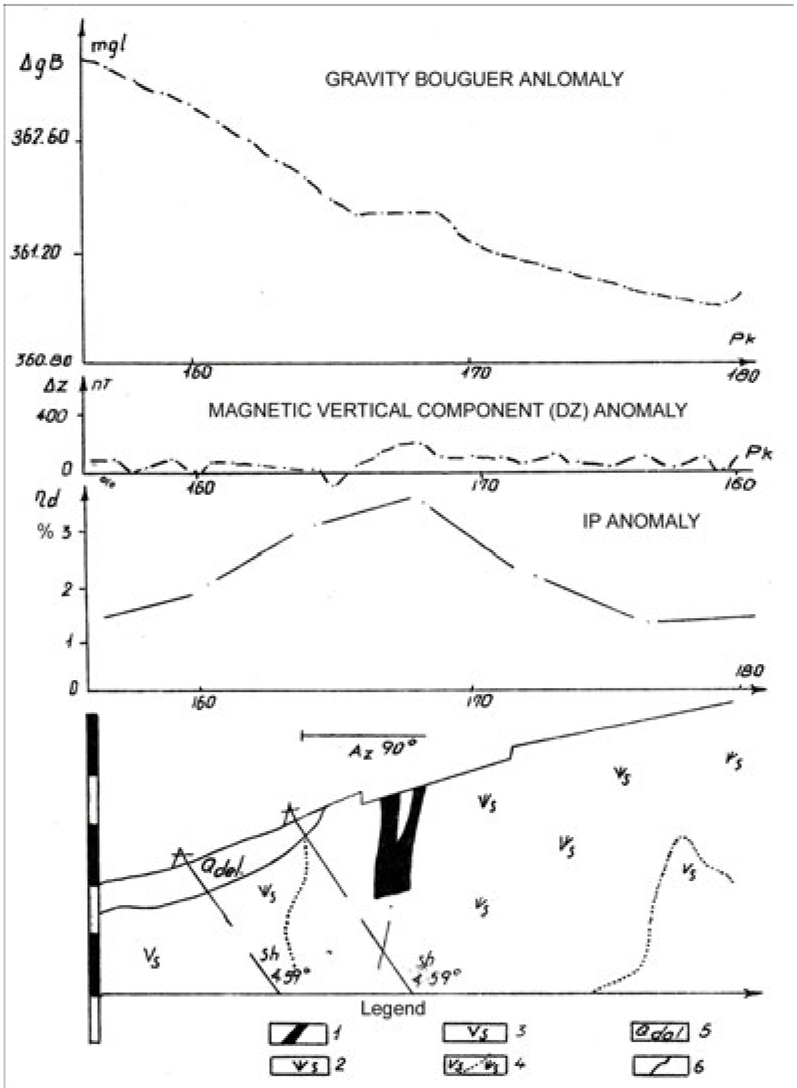

Fig. 4.65. Geological-Geophysical section in Qafe Gjela deposit (Bulqiza massif) (Prenga Ll. Et al. 1983).
1 - Ore body, 2 - Serpentinized dunite,
3 - Serpentinized hartzburgite, 4 - Smooth-rock border, 5 - Deluvion, 6 - Tectonic fault.

From this section can be seen that the IP anomaly is a rather wide one. This is due to the influence of ore body and its dunite envelope (fig. 4.66). Consequently a complicated wide anomaly is observed.

In fig. 4-67 is presented a magnetic anomaly over chromite ore in the Tplanë area.

b) Non-ore anomalies

During the geophysical mapping for the search for chrome ores, have been observed a lot of non-ore anomalies, due to many factors such as:

- Fresh rock inclusions between serpentinized rocks, which may create gravitational anomalies.
- Serpentinized rocks with high content of magnetite which can create magnetic anomalies, or induced polarization.

For example a magnetic anomaly of the amplitude -200 and +200 nT was caused by highly serpentinized dunites (fig. 4.68). IP anomalies can be observed, in these zones, as well.

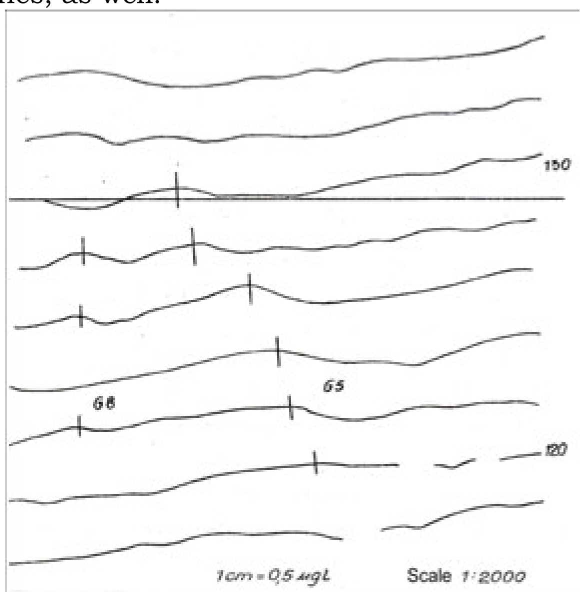

Fig. 4.68. The map of profiles of the total magnetic field intensity (ΔT) at Fushë Kalti zone (Bulqiza massif), where magnetic anomaly is observed over highly serpentinized belt and crushed dunitic inclusions have been observed (Sharra Xh., Rrënja A. et al. 1987).

Gravitational anomalies have been observed in zones with thin cover of soft overburden and compact bedrocks close to surface (fig. 4.69).

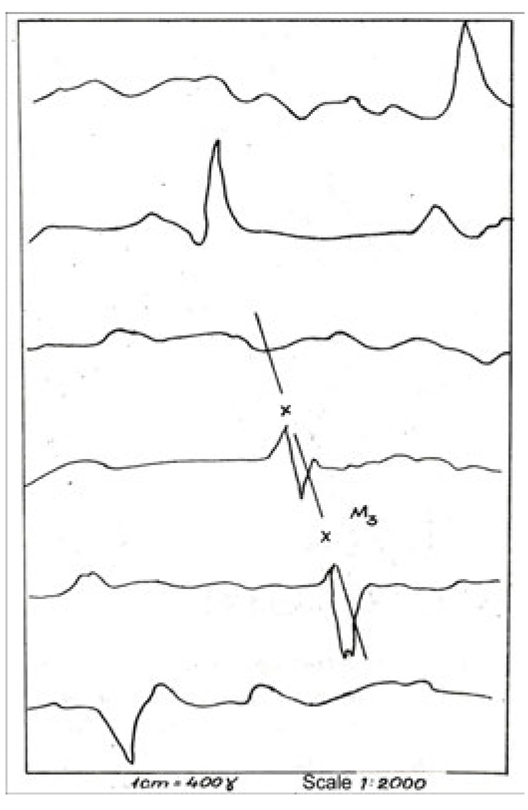

Fig. 4.69. The map of profiles of the Bouguer anomaly in Fushë
Kalti (Bulqiza massif), in a sector where are decreased the thickness of the soft overburden. (According to the Sharra Xh., Rrënja A. et al. 1987).

Prior to Bouguer anomaly interpretation, the thickness of soft sediments (deluvion and eluvion) was determined by apparent resistivity soundings. The main task of the interpretation was to selected the anomalies caused by ore bodies.

In fig 4-70 and 4-71 are presented magnetic anomalies over a non-magnetic rock individualisation between magnetic seprentites and pyroxenite vein , respectively, in Kam Tropoja deposit.

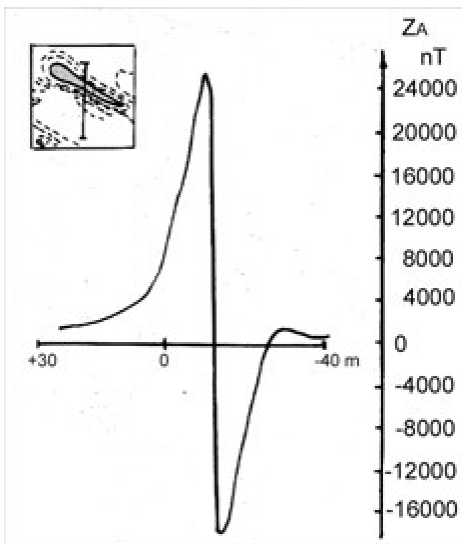

Fig. 4-71. Magnetic anomaly (ΔZ) over a pyroxenite vein, Kami deposit. (Fischer F., 1957).

4.3.2. Underground geophysical surveys

Underground geophysical surveys have been carried out in boreholes, in galleries and other mine works to solve the following problems:

a) <u>The search around mine works</u>

The search around mine works has been conducted in order to contour known ore bodies, especially those that are effected by tectonic faults, and to search for new ore bodies located around mine works. The goal was to increase the search depth and to get the available information for a sparse network of mine works at the first stage of the exploration.

Underground surveys can be made by all geophysical methods, which are used also by surface mapping. Radio wave floodlighting method can be used as additional ones.

The experience gained, especially during the eighty years period in Albania showed that the three components magnetic borehole method can be implemented successfully and efficiently for the search for magnetic chrome ore bodies. Typical example is presented the underground magnetic surveys in four boreholes in the Shkalla area, Bulqiza ultrabasic massif (Fig. 4-72) (Gjovreku Dh. 1984, Langora Ll. et al 1988). In the borehole No. 141 are observed two anomalies, at the depth 100 m and 140-180 m. The anomalies respectively have amplitudes: ΔZ=7 500 nT, ΔH=8 500 nT, and ΔZ=5000 nT, ΔH=8000 nT.

Fig. 4.72. Geological-geophysical section in L-L 5 underground magnetic survey line, Shkalla deposits, Bulqiza ultrabasic massif. (Langora Ll. et al. 1989)

According to the geological-geophysical interpretation of the data in the L-L 5, and L-L 6 lines result following conclusions:

- Chromite ore body must located about 30-40 m from line L-L 6.
- Northern prolongation of the ore body is about for 40 m.
- Other ore body causes second anomaly.

Projected boreholes have discovered ore bodies.

Fig. 4-73 shows the underground magnetic surveys in boreholes at Bulqiza deposit. The observed magnetic field in the borehole Sh. 4 represents an anomalous field above and underneath levels.

Borehole Sh.3 has intersected the ore body. The interpretation of the plots of the three component magnetic component Z and total magnetic component T showed that the ore body intersected by the bore hole Sh.2 in the forms of flexure is connected with the ore body intersected by the bore hole Sh.3.

In borehole S-17, which did not interest any orebody, an anomalous sector of the total magnetic field vector T at a depth of 190-330 m was observed (fig. 4-74). This anomaly was interpreted as being caused by a magnetic chromite ore body between the boreholes S-17 and S-16. The shallow boreholes S-1, S-2, S-3 and S-4 drilled at the end of gallery G-5 intersected the predicted ore body.

The outputs of the radio wave floodlighting and radio wave profiling give good results when the chrome ore is magnetic and has dense up to massive structure (fig. 4.29) The absorption coefficient values of electromagnetic waves of frequency 1 - 10 Hz for this area is b = (0.02-0.04) Neper/m, which is greater than for ultrabasic rocks (b = 0.0012-0.0015 Neper/m). The hologram of the fig. 4-75 show that maximal values of the image intensity are presented magnetic chromite ore body.

IP methods can be used for the search of polarised ore bodies around boreholes by using the pole-dipole array $N5M5A,B\rightarrow\infty$ and $N10M100A,B\rightarrow\infty$, which can investigate a zone of a radius 7m and 60m, respectively.

The results of underground survey are not affected either by complicated topography, or by alternated rock inclusion nearly to surface. Mine works, metallic equipment and geological heterogeneity have an effect on these results. To avoid these influences, underground surveying is carried out by a special methodology

and prior to the interpretation; the results are subjected to different mathematical processing.

b) <u>Well logging</u>

The geophysical methods have been used for geological documentation of the borehole trunk, ore bodies, tectonics faults and rock inclusions of different serpentinization degrees. Ore body thickness, deep layout, Cr_2O_3 content and the ratios Cr_2O_3/FeO, Cr/Al have been determined at a rather high accuracy.

The density is the more stable physical property, which in most cases is used for the selection of ore bodies from the surrounding media. The main method used for documentation of the borehole is the density and selective gamma-gamma logging (fig. 4.76.).

In the borehole log of the diffused gamma radiation (I_{gg}) the ore bodies can be outlined by radiation minimum, because they have higher density values than the surrounding rocks.

From this figure can be seen that a detailed description of the borehole geological section and more accurate evaluation, together with partial drill logs, can be made according to well logging data interpretation.

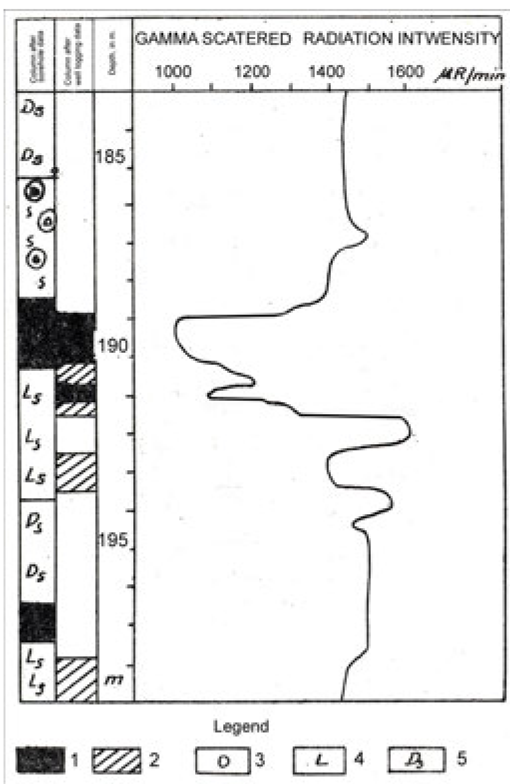

Fig. 4.76. Diffused gamma radiation log (I_{gg}) in Luçiane deposit, Bulqiza massif (after Nakuçi I. well logging).
1- Massive ore body; 2- Ore body with disseminated structure; 3- Dunites; 4- Hartzburgites; 5. Serpentinized dunites.

Minimum points have been also observed in fresh, non-serpentinized, rocks individualizations, situated between serpentinized rocks. For discriminating them

can be is used a selective gamma-ray logging. The intensity of smoothed component of scattered gamma rays, which is determined by heavy element content (as chrome) in the borehole section, is recorded by this logging.

Data on density gamma-ray logging can be used for the assessment of Cr_2O_3 content in the ores, for the computation of the ratios Cr_2O_3/FeO and Cr/Al, because it exist a correlation between the ore density and the Cr_2O_3 content, and between Cr_2O_3 and FeO and Al. Magnetic and polarisable ore bodies are very well distinguished through magnetic and IP well logging. Serpentinized rock inclusions with secondary magnetite situated between fresh rocks give clear anomalies. These last ones can be used as geophysical indicators to distinguish tectonic sequences from cumulate ones, etc.

Chrome ore bodies can also be discriminated from ultramafic rocks by other parameters such as the effective atomic number 19, cross-section capture 0.054 cm^{-1}, which are greater for hartzburgite and dunite (effective atomic number 12.5 and cross-section 0.0015 cm^{-1}), and characteristic gamma ray spectrum (for high energetic levels 8.5 and 8.9 MeV). Based on these characteristics different kinds of logs, such as the neutron-gamma spectrometric, neutron-neutron, thermal and overthermal neutron logging can successfully be used for geophysical documentation. Ore bodies can be distinguished by higher logging values than those of the surrounding rocks.

As it was mentioned above, it can be seen that, for the geophysical documentation of the borehole in chrome deposit, the basic method to be used should be the radiation logging (density, gamma-gamma, selective gamma-gamma, aluminium neutron-activation, neutron-neutron, thermal neutron and overthermal neutron logging). The magnetic, the IP and conventional resistivity logging can be used as additional methods.

4.3.3. Geophysical applications for geological mapping

Geophysical methods contributing to geological structural mapping purposes, aimed at successfully solving some regional and local problems. The structure of ultramaphic rocks massifs and their relationship with the surrounding media have been studied. Serpentinized and fresh rocks, tectonic and cumulate sequences have been discriminated by their serpentinization degree. Tectonic faults and deep elements of primary structures such as flow and banded structures, S, L and Q system of primary fissures, the individualisation of fresh and serpentinized rocks were mapped in the ore fields. The conditions of rock formation and their changes in space and time during the geological history have been studied for the mapped regions. During the exploration-developing stage have been studied, at a more detailed scale, the factors controlling the mineralization.

For accomplishing geological-structural mapping tasks, have been used different kinds of geophysical methods such as gravitational, magnetic, micromagnetic mappings; magneto-telluric and electromagnetic soundings; low and high frequency seismic prospecting for big and shallow depths studies, respectively. These works have been accompanied by petrophysical studies

Valuable information about the geology of Bulqiza ultramaphic massif and about other massifs has been received by gravitational mapping at the scale 1:25000 (Kosho P.). In the figure 4.77 is shown a geological geophysical line in Klos-Bulqizë-Shpuzë (Frashëri A. et al. 1990).

According to the interpretation of the Bouguer anomaly, the massif has an inverted conic shape. Its thickness is smaller at the edges and increases towards the centre (up to 5.5 km). Based on the distribution of the magnetic field, the

serpentinized sector of the ultramaphic rocks and the flanks where re massif is covered by the Neogene molasses sediments (especially the western flanks) have been mapped. The intensity of the magnetic field in these sectors is high due to the content of secondary magnetite. In plane, the anomalies have a mosaic picture, due to heterogeneous distribution of secondary magnetite. In these zones are also found some local minimums.

These characteristics can be used as features for the discrimination of cumulate sequences. Magnetic anomalies of cumulate sequence have high amplitude and high frequency.

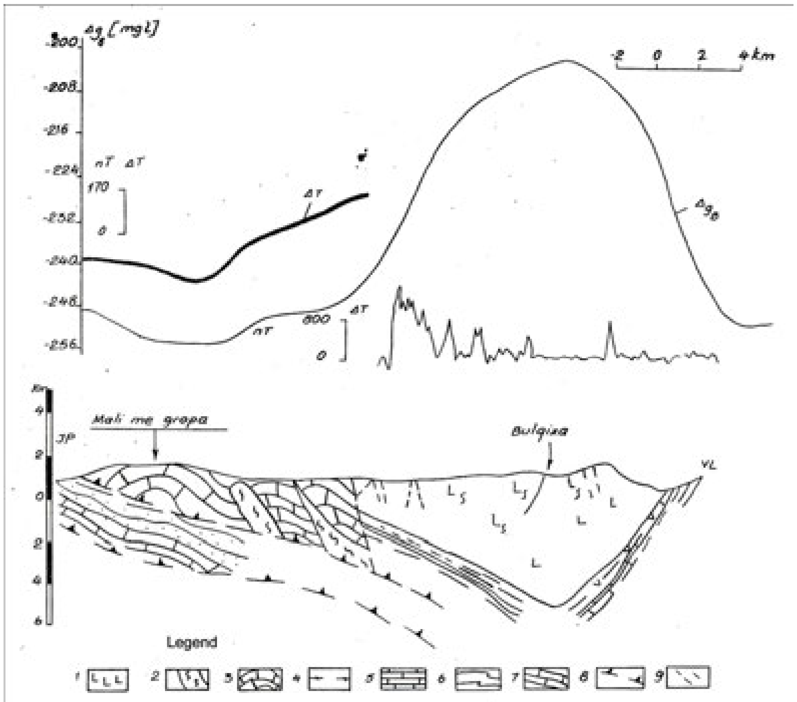

Fig. 4-77. Geological-geophysical line in Klos-Bulqizë-Shpuzë (Frashëri A. et al. 1990).
1 - Hartzburgites, 2 - Serpentinites, 3 - Triassic limestone, 4 - Volcano-sedimentary series, 5 - Jurassic limestones, 6 - Cr^2 - Pg^3 flysch, 7 - Pg^2 limestone, 8. Cover tectonics, 9 - Disjunctive tectonics.

Anomalies on dunite-hartzburgite tectonic sequences are characterised by smaller amplitudes and lower frequencies, meanwhile the intensity of the magnetic field is smaller than for hartzburgite-tectonite sequences. The correlation of different geophysical parameters, determines different perspective levels of ultramaphic cross sections, which help the search for mineralization.

Micro magnetic survey has given good results in determining the primary textural elements in zones covered by 2-3 m thick soft sediments and in zones where these elements cannot be seen. This is possible because the axis of the magnetic micro anomalies have two directions, one parallel with the fissures systems L, S and flow and banded textures, and the second one which coincides with Q fissure system.

The picture of the distribution of magnetic micro anomalies can be explained by the layout of the secondary magnetite mainly according to flow, banded textures and the fissures system L,S and C (fig. 4.78) and to the

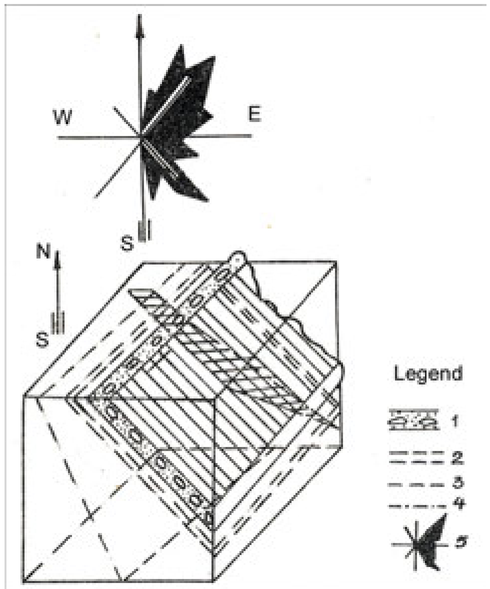

Fig. 4.78. Primary structural elements and the direction of the axis of magnetic micro anomalies. (Frashëri et al. 1969).
1 - Banded texture, 2 - Primary fissure system L, 3 - Primary fissure system S, 4 - Primary fissure system Q, 5 - Rose diagram and vectors of the direction of the magnetic micro anomalies axis.

direction of the vector of thermoremanent magnetization, which coincide with the direction of primary structural elements.

From the performed magnetic micro surveys, it seems that the axes of magnetic micro anomalies are the same for the dunitic rocks and the hartzburgite. That means that different kinds of rocks of tectonite-hartzburgite-dunite sequence have had the same development during the geological history. Dunites and hartzburgites can only be distinguished by unequal degrees of the serpentinization. The difficulty in distinguishing them is explained by the fact that these rock have physical properties which vary in a wide range and sometimes overlap each other.

Serpentinites, generally, have high contents of secondary magnetite and are magnetic. Therefore the magnetic surveying can be used to study the weathering layer for the search of nickel-silicates.

Geological geophysical studies of chrome ore fields have been carried out simultaneously with regional geological-geophysical mappings and petrophysical studies. These last ones have been used as a supplementary information source about the rock formation conditions, their composition and their changes in space and time. Such data are given in studies about the rock magnetism and its nature.

In the Tropoja ultramaphic massif has been observed an increase of the rock's density values, from the eastern part to the western one (particularly after Kami). That indicates that the rocks in the western part of this massif are less serpentinized than the ones in the eastern part. In the same direction can be distinguished the dunites from the hartzburgites of tectonic sequence. The hartzburgites have higher density values than the dunites. In the western part of the massif, is observed an increase of the content of pyroxenites inside hartzburgites and the degree serpentinization for these two kinds of rocks is different.

4.4 Some important conclusions and recommendations

Based on the results of geophysical investigations for the search of chromite in Albania and in other countries of the world, some conclusions can be made:

Geophysical anomalies are fixed on ore bodies and on rock inclusions. That means, not every anomaly may indicate about the presence of an ore body.
On chrome ores there are not always geophysical anomalies. That means that the lack of anomalies does not necessarily indicate about the absence of ore bodies.

The wide variation of the ore's physical properties and those of the surrounding rocks can explain these, by the small differences between these physical properties, by the shape and the small dimensions of ore bodies compared with their layout depth. Therefore, a geophysical anomaly can indicate only about the possibility of the existence of an ore body.

This anomalous situation is presented in the table 4.11.

In figs. 4-79 and 4-80 are presented a theoretical dependences of gravity anomalies (Bourguer reduction and vertical gradients) by mass/radius and depth of the ore body centres for a model in the sphere shape or horizontal cylinder, to have the possibilities to observed the anomalies, respectively with amplitudes 0,2 and 0,4 mGal, and 20 Oetvesh.

The characteristics of the anomalous geophysical picture, in the regions where chrome ore deposits are searched.

Table 4.11

Chromite ore and surrounding rocks	Gravity anomalies	Magnetic anomalies	Induced Polarization anomalies
Massive	+	+	+
chromites,			
magnetic and	+	+	-
polarizable			
Massive	-	+	+
chromites,			
magnetic,	-	-	+
unpolarizable			
Disseminates	+	-	-
chromites,			
magnetic and	-	+	+
polarizable			
Disseminates	+	+	+
chromites,			
nonmagnetic,			
polarizable	+	-	-
Fresh ultramaphic			
rocks			
Individualization			
Serpentinized			
ultramaphic rocks			
individualization			
Serpentinites			
intersected by			
gabbro-pegmatite			
dykes of cumulate			

sequence Gabbro pegmatite dykes or frech pyroxenites			

According to these calculations, by gravity surveys is possible to discover chromite bodies in different depth, from tens to hundred meters, if will exist necessary mass of the ore body. For example, the ore body with radius 14,5 m and mass 50.000 tons, is possible to explorer up to 23,5 m depth of location, because the Bouguer anomaly will has an amplitude about 0,2 mGal. The mass about 3.500.000 tons can be explored at 200 m depth of location, by survey such anomaly, 0,2 mGal.

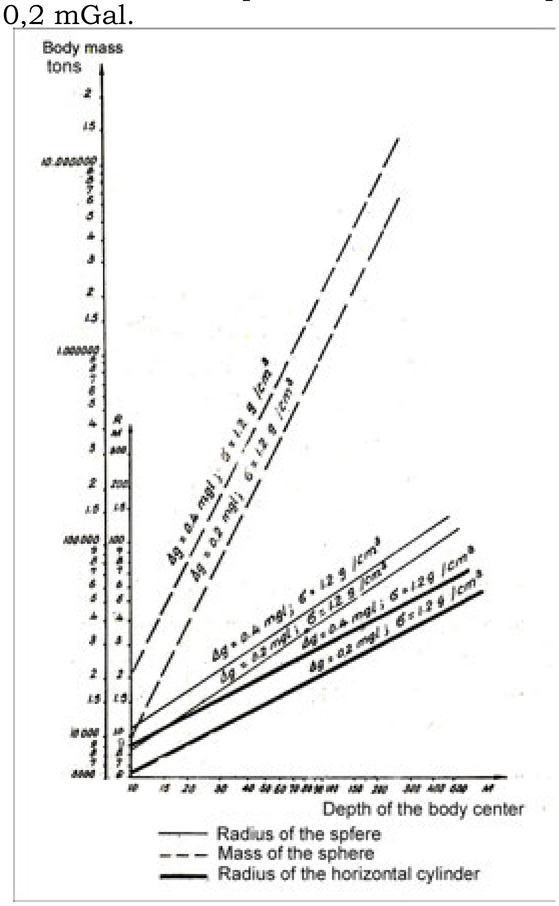

Fig. 4- 79. Theoretical limits of the ore body mass, for constant Depth of location of ore body, which will created an Bouguer anomaly of an amplitude Δg- 0,2 and 0,4 mGal. (Frashëri A. 1968, 1974)

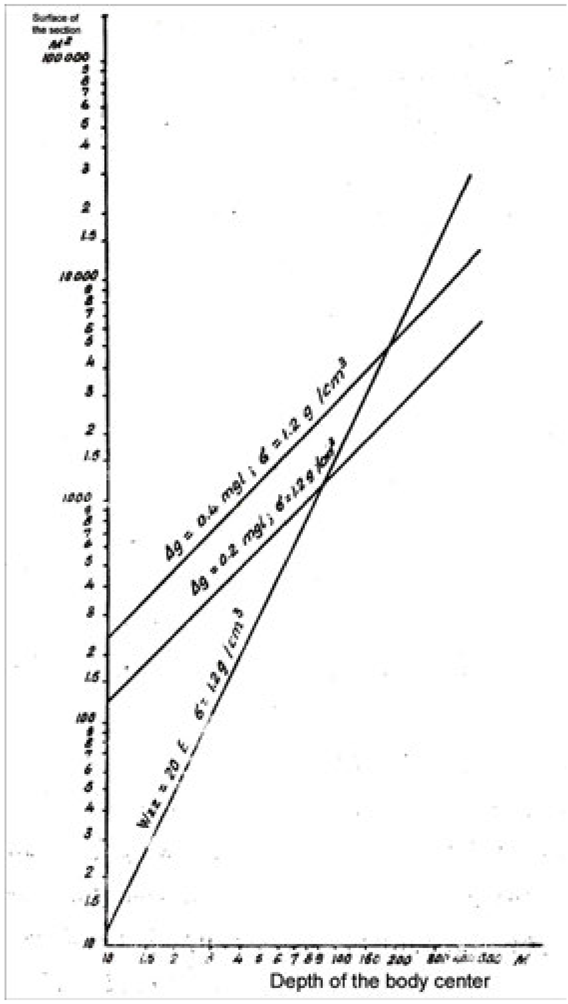

Fig. 4-80. Theoretical limits of the horizontal cylindrical ore body section surface, for constant depth of location of ore body, which will created an Bouguer anomaly of an amplitude Δg- 0,2 and 0,4 mGal and Wzz= 20 Oetvesh. (Frashëri A. 1968, 1974)

These limitations create the need for the implementation of some measures to increase the effectiveness of geophysical search:

Direct search for chrome ore bodies should be carried out simultaneously with the geophysical-structural mappings and petrophysical studies in order to know the factors controlling the mineralisation.

Surface and underground geophysical surveys (gravity, magnetic, geoelectrical ones) should be carried out in complexity. In the interpretation of the results should be considered all other existing geological information. This will make possible the determination of the nature of an anomaly, so that the ones caused by ore bodies can be selected. Better combination of surface with underground surveys leads to the increase of the search depth of the geophysical methods.

Geophysical works can achieve better results when perspective zones are the exploration objects. The work should start from well-known ore bodies and not from small sectors.

Geophysical studies should be carried out in the framework of complex geological studies. Only in this way can better be studied the geology of the

ultramaphic massifs, the premises for the search of ore deposits and ore bodies underneath the surface of the Earth.

Since the number of shallow or near- surface ore deposits is decreasing, the implementation of geological methods, at present, is a necessity in order to increase the search depth for chrome deposits.

COASTAL MANAGEMENT OF THE ECOSYSTEM VLORA BAY- NARTA LAGOON - VJOSA RIVER MOUTH.

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Abstract

The results of an integrated study, performed in the framework of DAC Program, concerning protection and management of Vjosa River and Narta Lagoon environment in Albania, financed by the Greek Ministry of Environment Planing and Public Works, and European Community, are presented in this paper. This is a scientific collaboration of Albanian scientists (University of Tirana and Academy of Sciences) and Greek scientists (Aristotle University of Thessaloniki and University of Athens, and Albanian Foundation "Spirit of Love".

Vlora Bay - Narta Lagoon - Vjosa River Mouth ecosystem is situated at the SE coast of the Otranto Strait. This ecosystem is distinguished for its particular natural individuality, and ecological values of international importance. The principal elements of the hydrological regime of the Vjosa River, the principal elements of the limnological regime of the Narta Lagoon, and the principal elements of the Vlora Bay in the Adriatic Sea in this paper are analyzed.

The ecosystem biodiversity and human activity impact are important part of the study. The study is based on information, which is collected during the monitoring in the framework of the DAC Project.

Key words: Vjosa River Mouth, Narta Lagoon, Vlora Bay, biotic monitoring, abiotic monitoring.

1. Introduction

Vlora Bay - Narta Lagoon - Vjosa River Mouth ecosystem, is located at the SE coast of the Otranto Strait (Fig. 1). This ecosystem, of great aesthetic value, distinguished for its particular natural individuality, and ecological equilibrium, constitutes the platform of the studies of the DAC project.

Vlora Bay is one of the most representative bays of the eastern coast of the southeastern Adriatic Sea (Photo 1, 4, 5).

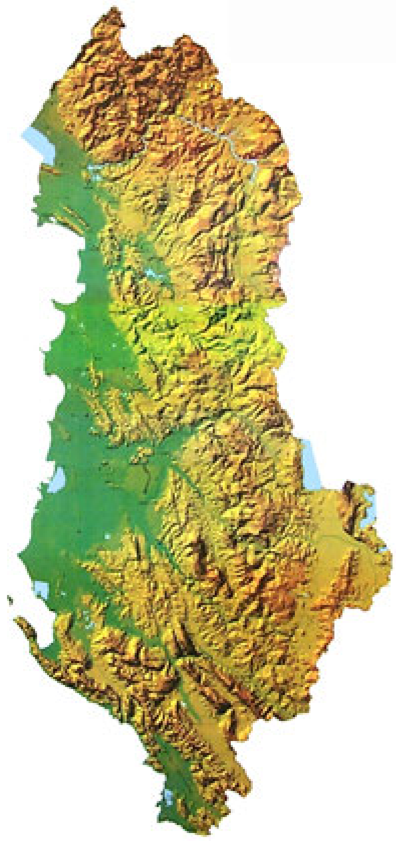

Fig. 1. Geographical Map of Albania

Photo 1-View of Vlora Bay

Photo-4- View of Coast of Vlora Bay

Photo-5- View of Coast of Vlora Bay

Vjosa-Aoos River is one of the biggest and most important rivers in the Albanian and Greek hydrography (Photo 2).

Photo-2- View of Vjosa River

The Narta Lagoon is one of the most important lagoons of Albania (Photo 3). This is situated in the northern part of the Vlora Bay, about 3 km from Vlora City. Two islands are located in the south part of the lagoon, with an approximate surface of 7 ha. The bigger of the two is covered with cypress. The famous Monastery of St. Mary, built in XIV century is situated in this island.

Photo-3- View of Narta Lagoo

Anthropogenic activities have a great impact on Vjosa River Mouth- Narta Lagoon- Vlora Bay water system. Both Albania and Greece do not have a regional or international program for pollution monitoring in Vjosa-Aoos River System. So the project DAC concerning the Vjosa River and Narta Lagoon, has created the conditions for the realization of a regional network for pollution monitoring. In this monitoring network physical-chemical, hydromorphological and biological approaches have been followed.

2. Material and methods

The geomorphological regime of the Adriatic Sea coastline, analyzes is based on the collection and examination of archival documentation (Topographic Map of Albania of Austro-Hungarian Institute, 1870, Military Geographic Institute, 1918 and 1938, Soviet Naval Institute, 1955, Albanian Military Topographic Institute, 1958, Landsat imagery of 1975, 1982, 1984, 2001 etc). Determination of littoral sediment transport and coastal sedimentation, the classification of erosion and accumulation processes under the wave refraction etc. are studied by analyzing of the archival materials and field surveys data.

Several physical-chemical parameters have been measured either in situ or in the laboratory. In situ measurements: Water velocity and discharge of the Vjosa River, pH, dissolved oxygen (D.O), temperature, conductivity and total dissolved solids (TDS). Water samples have been analyzed for the determination of the content of PO_4-P, NO_3-N, NO_2-N, ammonia N, and total suspended solids (TDS).

Length, the width and the depth of the Vjosa River bed have been estimated, respectively for the minimal, average and the maximal water levels. Water velocity and discharge in the channels from Narta Lagoon with Adriatic Sea has been estimated.

Lithology has been studied through geological maps, geophysical data, and during the field surveys. Granulometry of riverbed sediments have been estimated using the Wentworth scale.

Results of the observed data have been presented by graphic-analytic relations $R_o=f(Q_o)$ and $R_o=f(F)$, where Q_o is water discharge and R_o is suspended load discharge.

3. Analyses of the results

3.1. Hydrography

Aoos- Vjosa River flows in Greece and Albanian territory (Fig. 2,3). The Aoos river springs are located in the Smolek and Agos Mountain in Greece.

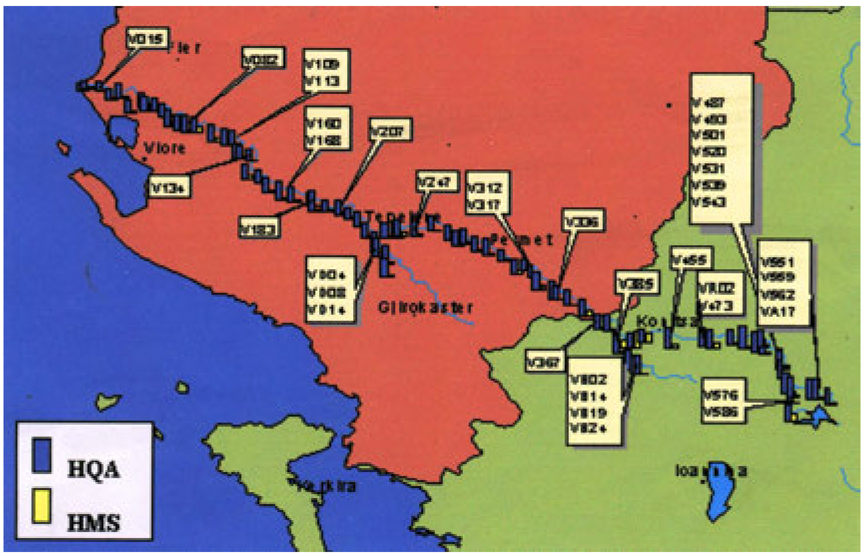

Fig. 2. Vjosa-Aoos River Minitoring

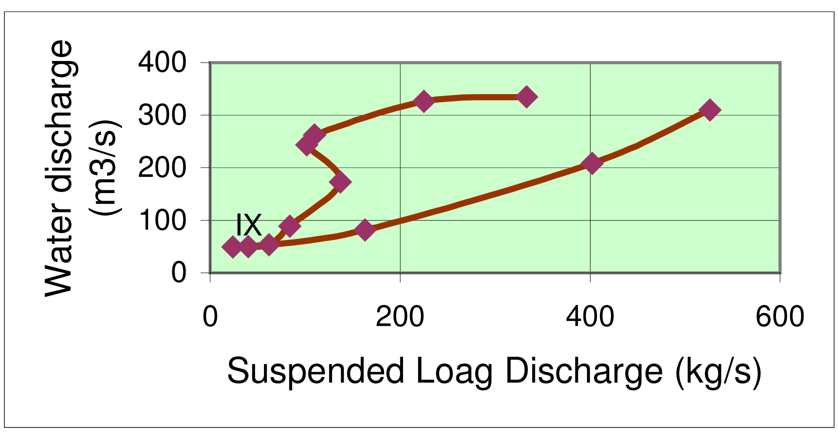

Fig. 3. Correlation between monthly-suspended load discharge (Rm) and monthly water discharge (Qo) of the Vjosa River in the Adriatic Sea.

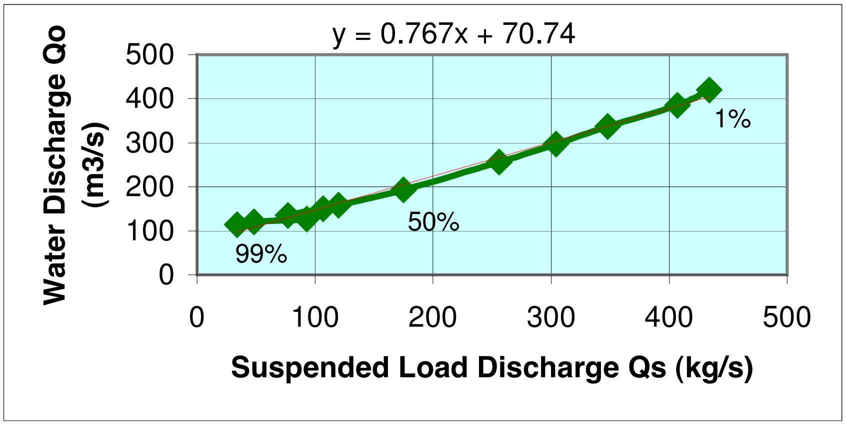

Fig. 4. Correlation between annual suspended load discharge (R_o) and annual water discharge (Q_o) of the same probability (p=1%-99%) by the Vjosa River in the Adriatic sea.

The main direction of the flow of the Vjosa River system is from SE to the NW, with a general tendency towards the coastal lowland from where it finally discharges into the Vlora Bay of the Adriatic Sea in Albania. The mouth of this river is situated in the northern area of the Narta Lagoon. Some of its main characteristics are the following: its catchment area is F=6710 km^2, the mean altitude H=855 m, the length L=272 km and the density of hydrographic network is D=2.2 km/km^2 (Pano N. 1984)..

The principal hydrological characteristics of Vjosa River System are presented in the Tab. 1. The average annual water discharge in Aoos-Vjosa River System ranges from Q_o=61.0 m^3/sec in Drino- Biovised area up to 164 m^3/sec at Vjosa River Mouth in Adriatic Sea. The minimum discharges vary respectively from Q_{min}=11.3 m^3/sec to 41 m^3/sec, to the maximum discharge Q_{max}=170 m^3/sec to 6130 m^3/sec. Equations describing mean annual water discharge (R_0) with the catchment area (F) for the main hydrometric principal axes of the Vjosa River are as follow:

$$R_o=0.00027.F^{1.55}; \qquad R^2=0.85; \qquad E_2=\pm 12\%$$

The main load suspend discharges ranges from R_o=53.3 kg/sec to 184 kg/sec.

The suspended load discharge of Vjosa River i the Adriatic Sea varies in very wide limits from R_o=480 kg/sec for the hydrological years of the low water discharge to R_o=3.8 kg/sec for the years of high water discharge. Correlation between monthly-suspended load discharge (Rm) and monthly water discharge (Qo) of the Vjosa River in the Adriatic Sea is presented in fig. 4. The dynamics of the change of the coastline in the Vjosa River Mouth is also determined by variation of the suspended load discharge impact of this river in the Adriatic Sea during the multi-annual cycles. Correlation between annual suspended load discharge (R_o) and annual water discharge (Q_o) of the some probability (p=1%-99%) by the Vjosa River in the Adriatic Sea is presented in fig. 5. Long-term distribution of the water and suspended load discharges of Vjosa River Mouth in the Adriatic Sea is presented in fig. 6.

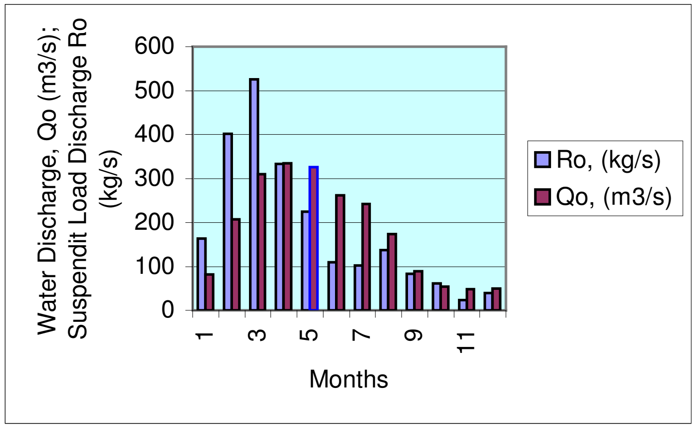

Fig. 5. Long term distribution of the water and suspended load discharges in the Vjosa River Mouth in the Adriatic Sea.

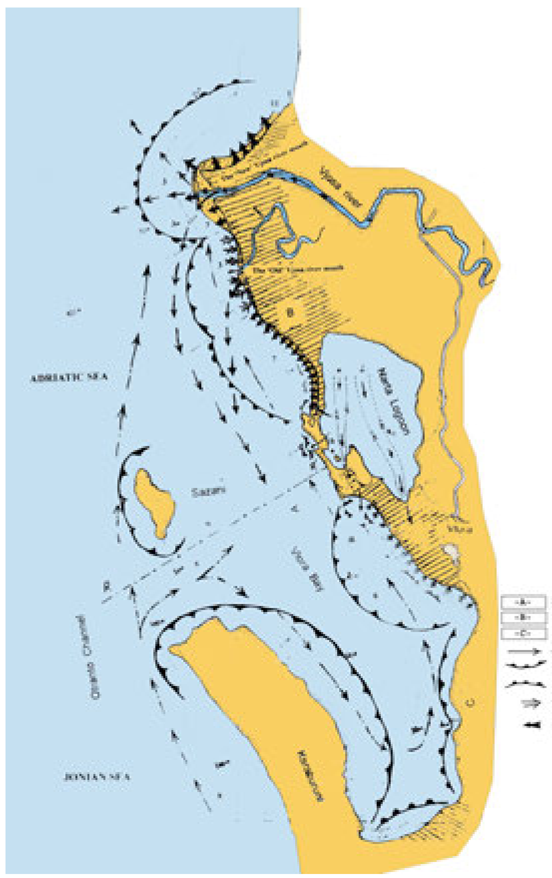

Fig. 6. General Evolution Map of the Vlora Bay-Narta Lagoon-Vjosa River Mouth coastline, during the period 1870-2001.

1) Coastline in 1870; 2) Coastline in 1992; 3) Sediment contribution; 4) “Old” Vjosa River Mouth; 5) “New” Vjosa River Mouth; 6) Coastal erosion; 7) Coastal sedimentation; 8) Sea current direction; 9) Line zero sediment transport.

Narta Lagoon has a surface of 41.8 km^2, the maximum depth 1.5 m and the average depth is 0.7 m. About 1/3 of its surface is used for salt extraction. Narta Lagoon is divided from the Adriatic Sea by the low hills of Zverneci- Treporti and by a littoral cordon of about 8 km long and width of 100-1400 m. The shape of the Lagoon is ellipsoid, with the main axe parallel to the coastal line. The Narta Lagoon is connected with the Adriatic Sea by two artificial channels, the South and the North Channel. The South Channel is 110 m long, 18 m wide, 1.67 m deep and the North Channel is 650 m long, 20 m wide and 0.54 m deep**.** Limniological regime of Narta Lagoon is determined by the hydrologic and climatic conditions of surrounding area and the water exchange degre with the Adriatic Sea. At the same time a shallow zone forms a barrier in the middle southwestern part. These conditions have an important impact in the general scheme of the geographical distribution of the limniological parameters in the Narta Lagoon.

The principal limniological characteristics of Narta Lagoon are: water balance the elements, water exchange intensity of from Narta Lagoon with the Adriatic Sea, the water temperature, etc. The annual precipitation rate is x_o=949 mm, with its minimum in July (22 mm) and maximum in November (148 mm). A water layer with an annual average of Z_o=1271mm evaporates in this lagoon, with its minimum in January (32 mm) and maximum in July (208 mm). Water exchange process between Narta lagoon and the Adriatic Sea is realized through two channels. The mean average discharge of this process is 1-5 m^3/sec. Narta Lagoon temperature rises from 1-7 ^oC to 29-40 ^oC.

The principal hydrochemical characteristics of the Narta Lagoon, as the dissolved Oxygen (O_2), salinity ($S‰_o$), pH etc, are presented in the Tab.2. The concentration of the dissolved Oxygen and other physical and chemical factors in Narta Lagoon water ranges widely in space and time. The O_2 in the Narta Lagoon water, during July 2001, rises from 3.45 mg/l to 8.19 mg/l and the salinity from 44.60 to 62.73 $‰_o$. The salinity from 46.70 $‰_o$ to 50.55$‰_o$ has been decreased during the December 2001. Evaporation of the Narta Lagoon water has greatly increased during the summers, with high temperatures. In parallel, the water exchange between sea and lagoon is decreased; the flow from the affluent basin is practically zero and the rainfall is almost completely absent. Under such conditions, the quantity of the water evaporating causes a great increase of the average salt concentration. The gradient of this change is increased in the relation with the distance from the lagoon inlets. During the winter the effect produced by the evaporation of the Narta lagoon meteorological conditions and the effect of drainage basin determine water shortage. The pH in the Narta Lagoon water depends on the concentration of bicarbonate and carbonate ions and dissolvent carbonic gas. In general, pH in this lagoon during July 2001 has risen from 7.5 to 8.4. Other physical-chemical characteristics of the Narta Lagoon: Nitrites (NO_2-N), nitrates (NO_3-N) etc are presented in the tab. 2.

Vlora Bay covers an important part of the southeastern coastline of the Otranto Strait. This Bay has a length of 36 km and 10 km width (Fig. 7). The maximal depth of this bay is 57 m. The coastline of Vlora Bay-Vjosa River Mouth area has continuously modified its configuration by sedimentation of alluvium transported by Vjosa River water and the swell of the Adriatic Sea. The coastal area is characterized by prevalence of winds blowing from the NW direction with a maximal speed 35-45 m/sec. The tidal range in this part of Adriatic Sea is low, reaching a maximum of 30-50 cm. The wave

action is characterized by calm in 35% of the cases, by wave with a higher of less than 0.5 m in 20% of cases and waves higher than 2.00 m in 3% of cases.

The general evolution map of coastline during the period 1870-2001 is presented in fig. 7**.** Sediment contribution, coastline configuration from 1870 to 2001 years, coastal sedimentation, erosion and accumulation processes, sediment transport, etc are presented in this map (Photo 4, 5). Many coastal transformations have taken place due to modifications caused by the river mouth migration, with the abandonment of old channels following a decreased discharge or creation of the new river mouths (Pano N. 1994).

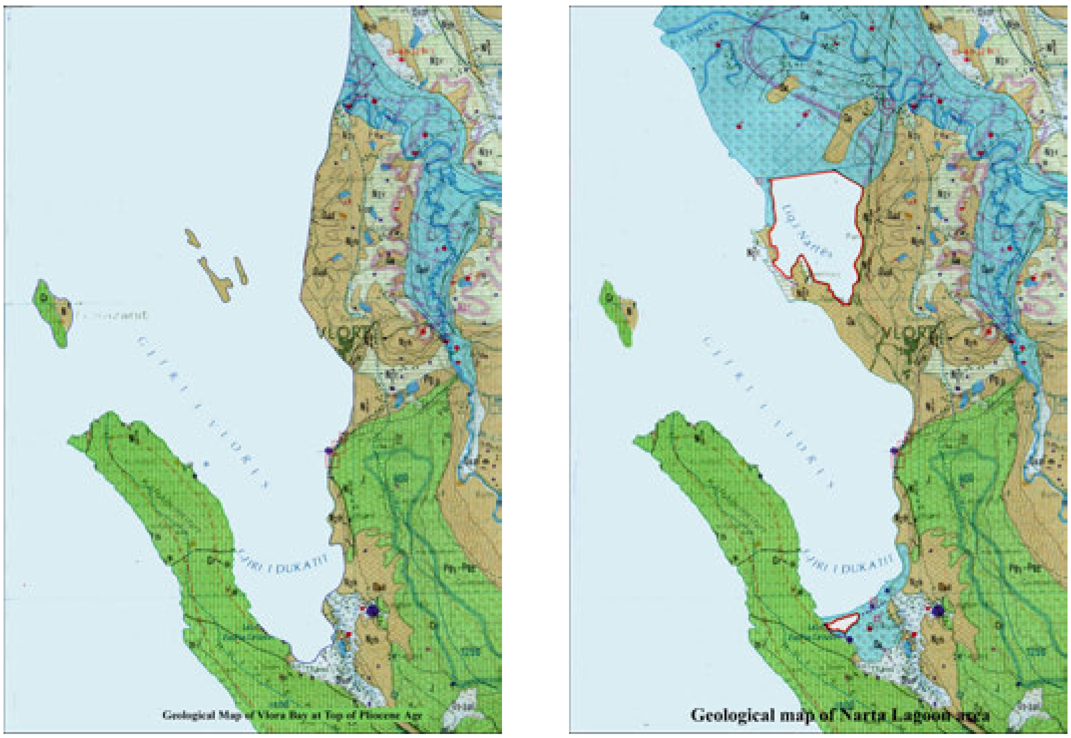

Fig. 7. Paleogeographic evolution of the Vlora Bay from End of Pliocene Age (a) up to Present days (B) (According to the Geological and Hydrogeological Map of Albania, at scale 1: 200 000, 1985, 1985).

Vjosa River Mouth has changed its position in the last century two times and these replacements have covered an area of the littoral about 10 km long in the northern direction.

The outlet of Vjosa River was shifted from position “A”- the old mouth to position “B”- the new mouth. The old mouth of this river is undergoing on important erosion process under the wave action. So there are important sources of coastal sediments in the coastline of Vlora Bay- Vjosa River Mouth area: First, the present Vjosa River Mouth and, and second the old Vjosa River Mouth.

The total Vjosa River sediment discharge in the Adriatic Sea is $W_T=7.5x10^6$ tons/year. About 20% of total sediment load equivalent to $W_F=5.6x10^6$ tons are the

bottom-load, and about 80% equivalent to $W_P=1.9x10^6$ tons are the sediment load. This river discharge is the main source of coastal sediments in Vlora Bay (Pano N., 1984).

The dynamics of solid deposits along the coastal zone and the accumulation intensity of sand are closely tied up with the warning process and particularly with the maximum wave effect.

The southward shift of the Vjosa River mouth during the XX century has created serious erosion problems in the northern coast of the Narta lagoon. The sediments input to the old delta ceased, the latter has almost been completely eroded and the sediment was removed to create a spit, which formed an accumulative zone in the southern part of the Vjosa River old mouth. This spit tends to vide of the littoral cordon of the Narta Lagoon in the west direction.

In Pasha Liman-Vjosa River Mouth coastal area, the corridor connecting Sazani Island in the West and Treport Hills in the East represents the line of zero sediment transport. In these conditions, the Vlora bay is an independent and separate geomorphological area, where coastal erosion processes dominate (Kedhi M. 1987).

3.2. Geological Setting and Quaternary Evolution

Geology, its dynamics, structure of hydric system, and climate have conditioned the morphology of the most beautiful Ecosystem, Vlora Bay and Narta Lagoon-Vjosa River Mouth, in the Adriatic Coast (Fig. 7-b, Photo 4).

Continental Area. Upper Cretaceous Limestone Mountain of the Karaburuni Peninsula, with 800-1600 m height encircles Vlora Bay at the southwestern side. In the South and eastern direction Vlora Bay is encircled by Mesozoic carbonate formation of the mountains: Llogara Col (1050 m), Çika Mountain (2045 m) and Lungara Mountain. Upper Miocene and Pliocene molasses and quaternary deposits fill Dukati Valley at the south side of the bay. In the north, the mountain chain is continued with Shashica hills. There lies the Aquitanian flyschoidal formation and Pliocene molasses of the Helmesi and Rogozhina suite of Panaja Hills (Geological Map of Albania, at scale 1:200 000 , 1984, Hydrological Map of Albania at scale 1:200 000, 1985).

Coastal Area. Limestone coast of the Adriatic Sea in Vlora Bay is generally abrupt. At the northwestern direction of the Vlora City, there is a coastline of the Albanian Adriatic Shelf. Narta lagoon was formed in a sea bay, which is closed by solid sediments transported by Vjosa River to the sea. The neotectonic phenomena also characterize the lagoon area. At southwestern direction, the Tortonian molasses Zvërneci hills chain from the isle separated Narta lagoon from the Adriatic Sea. Very interesting textures have been formed in this formation. Different sedimentological kinds and forms have represented these textures, with a scientific and didactic importance. There are observed many concretions and stamps. Geological section is extended from the beach to the northern direction and by erosion abrupt slope has been formed rising over the seaside. These characteristics make Zvërneci a rare geo-monument, with great international scientific, didactic, and tourist interest. These values and the beach beauty make Zvërneci area very attractive (Photo 6).

Around the Narta lagoonside the lagoon Quaternary deposits (Q_4^1) are extended. These deposits are represented by sky-blue-gray color silt, with silstone interbeds of gray color. Thickness of these deposits varies from 0.5-1 m up to 20-30 m. Lagoon deposits

have covered marine Quaternary deposits (Q_4^m). Marine deposits are represented by arkose sand, with green silty clay and gray silstone interbeds. Marine deposits are represented in the form of sand beach and dune belts. Quaternary deposit thickness is more than 100 m. At Aliban village airport area, 4 km north of Narta lagoon, lagoon and marine deposits have a resistitity of 0.37-086 Ohmm, up to the depth of 30.6 m. Under this depth, marine Quaternary sisltone sediments have a resistitity of 18 Ohmm. At Poro village, 8 km north of Narta Lagoon, according to the electrical sounding results, up to the depth of 14 m deposits with a resistivity of 6.4-21.9 Ohmm are extended, which are represented by clay and silstone. Under these deposits, a layer with a resistivity of 2 Ohmm, and thickness 31 m is extended. Very low values of the resistivity shows that this layer is presented by sand saturated by saline water. The same phenomenon was observed by electrical soundings at Pisha village area, at the northern side of Vjosa River. But here, deeper than 25 m, a saturated by saline water sand layer is extended (Frasheri A., 1962, Kapllani L. et al. 1995, 1996).

Marine deposits, filling the coastal plain of Orikum, are in the south side of Vlora Bay.

Vjosa River flows through Periadriatic Depression. In plain area, the valley is wide and many meanders are formed by river. Through the Quaternary deposits (Q_4) Vjosa flows from Panaja to the Adriatic Sea. Clay, silstone, sand, and gravel or clastic materials in some areas compose these deposits (Frasheri et A., 1996). At Panaja area, Quaternary valley deposits are extended up to 4 km.

Marine Area. Offshore Later Quaternary Marine deposits (Q_4^m) in the marine area of Vlora Bay according to the electrical marine soundings and shallow boreholes, are 190 m thick (Fig. 8). At the western direction of the Zvërneci Hills, these deposits are covered the Tortonian molasses.

Configuration the Vlora Bay has started to form from the Pliocene age, when the molasses of the Panaja Hills have been outcropped at surface (Fig. 7-a). Actually, Later Quaternary Marine deposits (Q_4^m) are created the present Vlora Bay (Fig. 7-b).

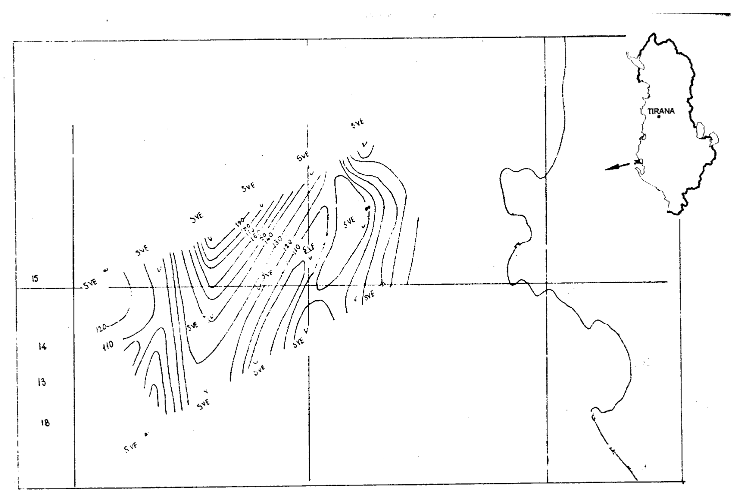

Fig. 8. The offshore floor configuration of the Quaternary Marine deposits in Vlora Bay, according to the marine electrical soundings data

Agricultural soils. Different kinds of agricultural soils are extended in the area (Cara K. et al. 1996, Cara K. et al. 2000, Gjoka F. et al. 2000, Pedological Map of Albania, Zdruli P. et al. 1995). Their thickness is over 1 m. In the lower parts of these soils, the subargille thin interbeds have been observed. Agricultural soils have covered the lagoon deposits. According to the electrical soundings and pedological studies, agricultural lands at the north of the Narta lagoon are saline soils. Considerable soluble mineral salt quantity, in particularity natrium, contents the upper soil layers, and the lower ones, too. Salt content varies from 0.3%-3 %, and in some cases up to 15%. Alluvium soils, which are extended near the riversides are represented by coarse alluvium (sand, clayed sand, and silty clay) and are poor of aliment matters. Heavier and richer with aliment matters are the soils, which are located farther from the riversides.

3.3. Biology, physicochemical parameters and anthropogenic impacts of the Narta lagoon

Narta Lagoon is considered as one of the most important wetland areas of Albania for its biodiversity and the number of habitants. Narta natural ecosystem is an important part of natural potential of Europe and a complex of international importance. Birds are the most important group of all with 182 winter inventories that register an average a number of 18700 waterflows. The area fulfils the criteria of Ramsar Convention (Bino T., 2000). The Narta lagoon is characterized as a Geo-monument of international importance (Seriani A. 1991, 1999) and as a Special Protected Area for birds.

Neither the analyses of the physicochemical characteristics that took place during the present study nor the benthos, that predictably consisted of taxa tolerant to organic pollution since the substrate is silty, did directly detect any important problems of pollution. The soil industry is extracting water from the lagoon without a preliminary study. In the surrounding area of the lagoon, oil is drilled and gas is extracted from deep wells. But intensive agricultural and industrial activities, as well as the development of tourism, without being based on a management plan, may provoke serious problems to the lake in the future. The most important danger that the lagoon confronts is the imminent isolation from the sea. In the Narta Lagoon are observed intensive solid deposits of the Vjosa River on the coastal area tending to stop the active water exchange between the lagoon and the sea resulting in lack of fresh water in the lagoon. Dirty untreated urban water flow also exists in the lagoon.

The same anthropogenic impact is observed in the Vlora bay: flow of the dirty untreated urban and industrial water in the sea, exploitation of the sand and gravel from beaches for constructive materials, deposition of the solid industrial waters (Cu, mercury, clay etc) in the onshore and offshore coastline.

Biodiversity of the Narta Lagoon area:

Birds: Pelecanus crispus, Platalea leucorodia, Phoenicopterus ruber roseus, Anas penelope, Anas crecca, Bucephala clangula, Oxyura leucocephala, Haliaeetus albicilla, Aquila clanga, Falco naumanni, Recurvirostra avosetta, Larus genei, Sterna albifrons, Steptopoelia turtur, Strix aluco (Bino T. 2001).

Fish: Mugilidae, Maronidae, Sparidale, Atherinidae, Anguillidae, Cyprinodontidae+Poecilidae, Sparidae (Rakaj N. 2001).

Amphibia: Triturus criststus, Triturus vulgaris, Mombina variegata, Bufo bufo, Hyla arborea, Bufo viridis, Rana dalmatina, Rana balcanica.
Reptiles: Emys orbicularis, Mauremus caspica, Testudo caretta, Caretta caretta, Hemidactylus turcicus, Lecerta trilineata, Lacerta muralis, Coluber jugularis, Elaphe loghissima, Malpolon monspensulanum, Natrix natrix, Natrix tesellata, Vipera ammodytes.

3.4 Biology , Hydromorphology , Habitat Survey of the Vjose river and Environmental impacts.

According to the sampling results of the Aoos-Vjose river benthic fauna, the latter was diverse and included many sensitive to organic pollution taxa, except from two sites during the high flow season. First site is located near the river mouth, which were affected by oil and sand extraction in the area. Memaliaj coal mine waste and Gorisht-Kocul-Gernec oil reservoir and Selenica bitumen mine wastes in the Vjosa River catchment create pollution of soils, surface and underground waters. Unfortunately, this environmental human activity has caused the decrease of surface and impoverishment of the soils. Based on the biotic indices, the water quality appears to be excellent in all the sites except from these two last ones, which consist of poor fauna mainly due to the oil plants, therefore more effective technology in the extraction process is recommended. Aoos – Vjose river differs from all the rest of the studied rivers in the northern part of Greece which have never had such an excellent quality of water all the seasons long (Kamba et al, 2000; Lazaridou et al, 2000).

Additionally, the physicochemical characteristics also confirmed this status. As to the collected fish fauna, it consists of seven freshwater species in the Greek part of the river and of 18 species in total, five of them common in the Hellenic and the Albanian part, including species of the family Acipenseridae, that are protected. The avifauna also consisted of many species, almost 200, three of them being in danger universally.

As to the habitat quality of the Aoos-Vjose River, it was found that it is of the few least modified rivers in Europe. That is why the qualification score (structure of habitat) is very high in most of the studied sites. However, the relatively high modification score of the river habitat at certain parts is due to dams, quarrying (sand/gravel extraction) and water abstraction for irrigation purposes. Consequently, better planning or enforcement of the existing law for such activities is necessary to prevent serious degradation.

Vjosa valley ecosystems, from the Albanian-Greek frontiers up to the river mouth at the Adriatic coastline, confront though many problems: erosion, pollution of the soil and waters, loss of the land and water habitats, fractures in the biodiversity, land fragmentation and progressive impoverishment, salinity etc. that have caused their degradation. This degradation has attained stability and productivity of agricultural ecosystems.

Very intensive erosion in Vjosa catchment area provokes great quantity of solid material, which is transported by the river. This erosion is caused by many factors:

Firstly, in Vjosa cathchment area high precipitation takes place. Vlora has in average 954.8-2405 mm/year precipitation. Soils and rocks have a great erodibility, and are without organic matter. Shallow and tilt agricultural soils are the result of this intensive erosion that is intensified by human activities:

a) Abusive deforestation during the last years, opening new agricultural lands and their intensive cultivation, destruction of the meadow and permanent pastures, and missing of the adequate land protection (Gjoka F. et al. 2000).
b) Exploitation of the gravel and sand in the riverbed.

Discharge of untreated urban waters from many dwelling centers into the river, and deposit of solid urban waste in the riverbed are caused great polution of hydric system.

Biodiversity of the Vjosa-Aoos River:

Amphibia: Salamandra salamandra, Triturus cristatus, Triturus vulgaris, Hyla arborea, Rana graeca, Rana lessonae, Rana balcanica, Rana dalmatina, Bufo bufo.

Birds: Ardea cinerea, Neophron percnopterus, Gyps fulvus, Accipiter gentiles, Aquila chrysaeatos, Falco peregrinus, Bubo bubo, Dryocopus martius, Dendrocopos leucotos, Cinclus cinclus, Monticola saxatilis, Monticola solitarius, Parus lugubris, Sitta europaea, Sitta neumayer, Tichodroma muraria, Loxia curvirostra (Bino T., 2001).

Fish: Acipenseridae, Salmonidae,, Clupeidae, Cyprinidae, Barbus, Barbus graceus, Chondrostoma nasus nasus, Pseudorasbora parva, Pachychilon pictum, Paraphoximus epiroticus, Leuciscus illyricus, Anguillidae (Rakaj N. et al. 1995, Rakaj N. 2001).

Reptiles: Emys orbicularis, Mauremys caspica, Testudo hermanni, Caretta caretta, Hemidactylus turcicus, Lacerta trilineata, Lacerta viridis, Padarcis muralis, Coluber jugularis, Elaphe longissima, Malpolon monspensulanum, Natrix natrix, Natrix tesellata, Vipera ammodytes.

4. The conflicts in the Albanian part of Vjosa River and some managerial propositions.

• The rising building sector and quick uncontrolled industrial development, in Albania, is connected with gravel/sand extraction, which form an extremely difficult problem to solve.

• The overthrow of trash into the river is inevitable because of the lack of an appropriate waste disposal management system while at the same time the river is used by the locals for recreational purposes and fishing.

Therefore the need for rise the locals' awareness on environmental issues through seminars, information centers etc. is recommended. Such a prospective could affect positively the already developed ecotourism and promote sustainable land uses and activities in the area. Better understanding of the natural processes, with the income compensation by the ecotourism, in combination with better planning and management of the area could lessen the conflicts and lead the region into sustainable economic development.

5. Acknowledgments

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Photo-3- View of Narta Lagoo
Photo-4- View of Coast of Vlora Bay
Photo-5- View of Coast of Vlora Bay

Tab. 2-1

PHYSIC-LIMNIOLOGICAL PARAMETERS AT THE NARTA LAGOON

No	Sites	Data	Hydrographical Parameters		Physic-chemical Parame				
			Coordinates	Depth H (in m)	Level	t ^0C	PH	O_2 (mg/l)	NBO_3
1	1 N	13. 07. 2001	44° 86 850 N	-0.30	Min.	33.2	8.2	3.45	6.75
			43° 68 160 E		Mean				
		12. 12. 2001			Max.				3.85
2	2 N	13. 07. 2001	44° 88 200 N	-0.40	Min.	31.4	8.0	5.46	2.15
			43° 67 710 E		Mean				
		12. 12. 2001			Max.				3.00
3	3 N	13. 07. 2001	44° 88 125 N	-0.35	Min.	29.4	8.0	4.73	0.85
			43° 64 890 E		Mean				
		12. 12. 2001			Max.				1.70
4	4 N	13. 07. 2001	44° 89 520 N	-0.45	Min.	29.7	7.8	5.27	0.75
			43° 65 110 E		Mean				
		12. 12. 2001			Max.				2.80
5	5 N	13. 07. 2001	44° 89 660 N	-0.60	Min.	31.2	7.6	4.91	0.55
			43° 67 470 E		Mean				
		12. 12. 2001			Max.				2.80
6	6 N	13. 07. 2001	44° 90 110 N	-0.35	Min.	32.3	7.5	7.28	0.38
			43° 69 100 E		Mean				
		12. 12. 2001			Max.				1.00
7	7 N	13. 07. 2001	44° 91 530 N	-0.55	Min.	31.2	8.4	6.15	0.87
			43° 64 700 E		Mean				
		12. 12. 2001			Max.				0.85
8	8 N	13. 07. 2001	44° 91 740 N	-0.60	Min.	31.8	8.2	8.19	1.55
			43° 66 470 E		Mean				
		12. 12. 2001			Max.				0.90
9	9 N	13. 07. 2001	44° 92 110 N	-0.35	Min.	31.8	7.7	6.00	1.30
			43° 68 210 E		Mean				
		12. 12. 2001			Max.				1.20

OUTLOOK ON SEAWATERS DYNAMICS AND GEOLOGICAL SETTING FACTORS FOR THE ALBANIAN ADRIATIC COASTLINE DEVELOPMENTS

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Abstract

Results of integrated hydrographical studies and offshore and onshore geological-geophysical surveys in Albanian Adriatic Littoral are presented in this paper.

According to the evaluation of the discharge regime in Albanian rivers system and its impact on the hydromorphology of Adriatic Sea, the river bed deformation, migration and new river mouths investigations, seismic and geoelectrical marine and onshore surveys, geological onshore mapping and underwater offshore sampling, boreholes and oil and gas depth wells, geodesic and bathymetric mapping have been classified the segments which have different geomorphology with in mainland and in marine area of Albanian Adriatic Shelf. Accumulative coastlines are extended at plain areas. Beautiful sandy beaches and dunes are main elements of these areas. Marine Quaternary deposits from plain sea floor up to some kilometers in the land have e thickness from some to hundred meters. Narta, Karavasta, Viluni, Patoku and Kune-Vaini Lagoons are located in plain area of the littoral. These lagoons are formed in some sea bays, which are closed by solid sediments transported by rivers to the sea. Erosive coastlines are extended in the hilly base of some capes. The hills are presented northwestern part of the Neogene's anticlines. Sandstone banc are extended in the sea floor. Neotectonic development at the present has caused submergence of three sectors within the accumulative areas.

1. Introduction

The Albanian coastal area on the East of the South Adriatic and North Ionian has a length of 447 km long (Fig. 1). This area represents the Easter side of Otranto Strait. River mouths and deltas, lagoons system, abandoned riverbeds, marsh labyrinths, sandy beaches, dunes covered with vegetation, dense forests represent Albanian littoral.

According to the studies conclusions results that geomorphologic classification of the Albanian coastal area consist of two principal major paleogeographic zones (Fig. 2, 3):

1- Adriatic Coastline of Peri-Adriatic Depression in the central and northwestern part of Albania. There are three different segments:

- Accumulative segments, which represent main part of the coastline,
- Erosive segments, and
- Submerged littoral areas, where is observed marine ingression toward the mainland.

The Adriatic coastline dynamics geomorphology is conditioned by geological setting of the western side of Albanides, by the neotectonic developments, by the dynamics of the

seawaters, solid material discharge from Albanian River network to the Adriatic Sea, and their deposition along the coastal zone.

- 2- Erosion coastline of Ionian tectonic zone in the southwestern part of Albania
-

2. Material and methods

- Marine and onshore-integrated surveys and studies for the investigation, monitoring and estimation of the physical characteristics of the Albanian coastal area have been performed during the period 1958-2005.

2.1. Hydrological and hydrogeomorphological, were based on the information of the Albanian hydrometric network that consists more than 220 meteorological and hydrometric stations, during the observed period of 20-100 years data of Albanian Hydrometeorological Institute. There are also 8 coastal stations and 12 other stations installed in the flow of the most important Albanian rivers near the sea.

2.1.1. Hydrological studies: Multi annual hydrometric observations on water levels, temperatures, water discharge into the Adriatic Sea, suspended material discharge; alluvial granulometric composition, water chemical composition etc. were performed in main Albanian rivers. Water potential and run-off discharge regime of the Albanian Mountainous River System have been evaluated by a specific way for two categories of river basins (Pano N. 1984, 1998):

1) Drini, Mati, Ishmi, Semani , Vjosa River systems, etc., where the run-off discharge depends from the altitude of the water level river section.

2) Scutary Lake-Drini River-Buna River water system, where the discharge of the Buna River, which flows away from the Scutary Lake (Q_2) to the sea, depends from the level of the water (H_2), and by the Drini River discharge in to the Buna River (Q_4):

$$Q_2 = \left\{ 0.025 \cdot \left[H_2 - \frac{Q_2^2}{(0.0073 \cdot H_2^{1.61413})^2} \right]^{1.85} - Q_4 \right\} \qquad (1)$$

The calculations have been performed for the models of dry and wet characteristic years. The evotranspiration potential have been calculated by different well-know methods.

Several physical-chemical parameters have been measured: the water velocity and discharge of the rivers and from the lagoons to the Adriatic Sea and to the Ionian seas, and the chemical water content.

2.1.2. Hydrogeomorphological studies *w*ere performed to evaluate the geomorphologic characteristics, the evolution and the migration of Albanian Adriatic coastline.

The marine current analyses are based on examination of the filed surveys data and oceanological calculation. The oceanological calculations are realized by dynamic method. This method based on formula:

$$u(z) - u(H) = \frac{10\Delta D}{2\varpi h \sin\alpha} \qquad (2)$$

Where: u(z) – the current speed in the sea surface (z=0)
u(H) – the current speed in the calculate surface
ΔH - the difference of the dynamic altitude
w - the vector of the speed
L - distance from two hydrological stations
α - geographical altitude

The wave refraction in the coastal area is analyses by wave refraction diagrams, by numerical methods solving of system of equations:

$$\begin{cases} \dfrac{d\theta}{dy} = \dfrac{1}{C}\left(\dfrac{\partial C}{\partial x} - ctg\theta \cdot \dfrac{\partial C}{\partial y}\right) \\ \dfrac{dx}{dy} = C \cdot tg\theta \end{cases} \qquad (3)$$

Where: $\theta(x, y)$ - is the angle between the x axis and the tangent of the wave rays at point M(x,y).

C(x,y) – is the wave speed and the same point

(x,y) - is the coordinates of the region.

The geomorphological regime of the Adriatic Sea coastline, have been analyzes based on the examination of archival documentation (Topographic Map of Albania of Austro-Hungarian Institute, 1870, Military Geographic Institute, 1918 and 1938, Soviet Naval Institute, 1955, Albanian Military Topographic Institute, 1958, Land sat imagery of 1978, 2000, 2002 etc). Determination of littoral sediment transport and coastal sedimentation, the classification of erosion and accumulation processes under the wave refraction etc. are studied by analyzing of marine and onshore surveys data.

2.1.3. Limnological observations on the Albanian lagoon system were performed in hydrometric stations and by periodical expeditions for study of the water physic-chemical characteristics, measuring the discharge in the water channels with the sea, sediment granulometrical analyses, and the evaporation of the lagoon water surfaces

2.2. Oceanographic studies: Water levels, temperatures and chemical content atc., formation and circulation of the water mass, wave and wind regimes of the Adriatic and Ionian coastline have been study in the hydrometric station network since 1958. Two Albanian oceanographic expedition "Saranda-1963" and "Patos-1964", and two joint Italian-Albanian expeditions "Italica I -2001" and "Italica II-2002" were organized in the Southern Adriatic and Northern Ionian.

2.3. Integrated geological-geophysical: onshore surveys of the Albanian littoral areas have begun since 1958. Offshore geological-geophysical surveys on the Albanian Adriatic shoal shelf have started from 1976 (Fig. 1, 2). Marine geological mapping has been performed using submarine surveys, shallow mapping boreholes and dredge's sampling. Integrated offshore geophysical surveys have been carried out using reflection seismic of shoal littoral shelf, marine electrical soundings and profiling of apparent resistivity, marine magnetic recognition surveys and marine radiometric surveys. Offshore geological-geophysical surveys were performed in the shoal littoral shelf, with a width of 5-10 km parallel to the coastline. Electrical soundings have a depth of investigation is about 1000-1500 meters, and influence depth is up to 3000 meters.

2.4. Climate change was analyzed by inversion of the ground surface temperature history, using the temperature record in the deep wells and shallow boreholes, and by the meteorological observations data. Have been study the climate change impact on the Adriatic Sea hydrology and on the erosion process in the Albanian River Network.

3. Regional hydrographic outlook on the Albanian Littoral

The Albanian coastal area lies from Shëngjini to Vlora bays and Northern Ionian Sea, from Vlora to Saranda bays at the south (Fig. 1, 2).

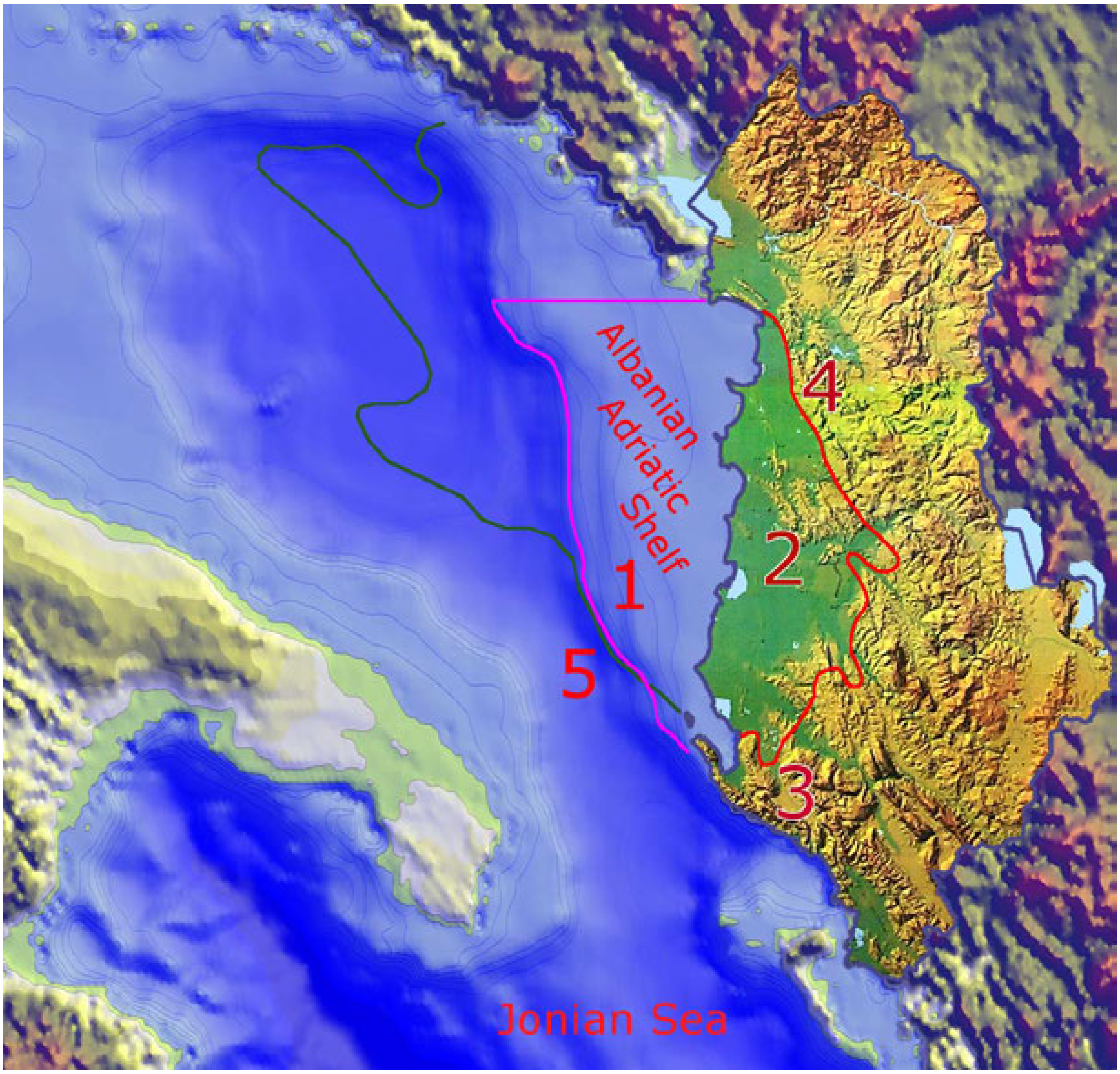

Fig. 1. Albanian Adriatic and Ionian Seas coastline area.
1. Albanian Sedimentary Basin; 2- Periadriatic Depression; 3- Ionian tectonic zone; 4- Kruja (Gavrovo-Dalmatic-Montenegro) tectonic zone; 5- Apulia platform, Paksos zone.

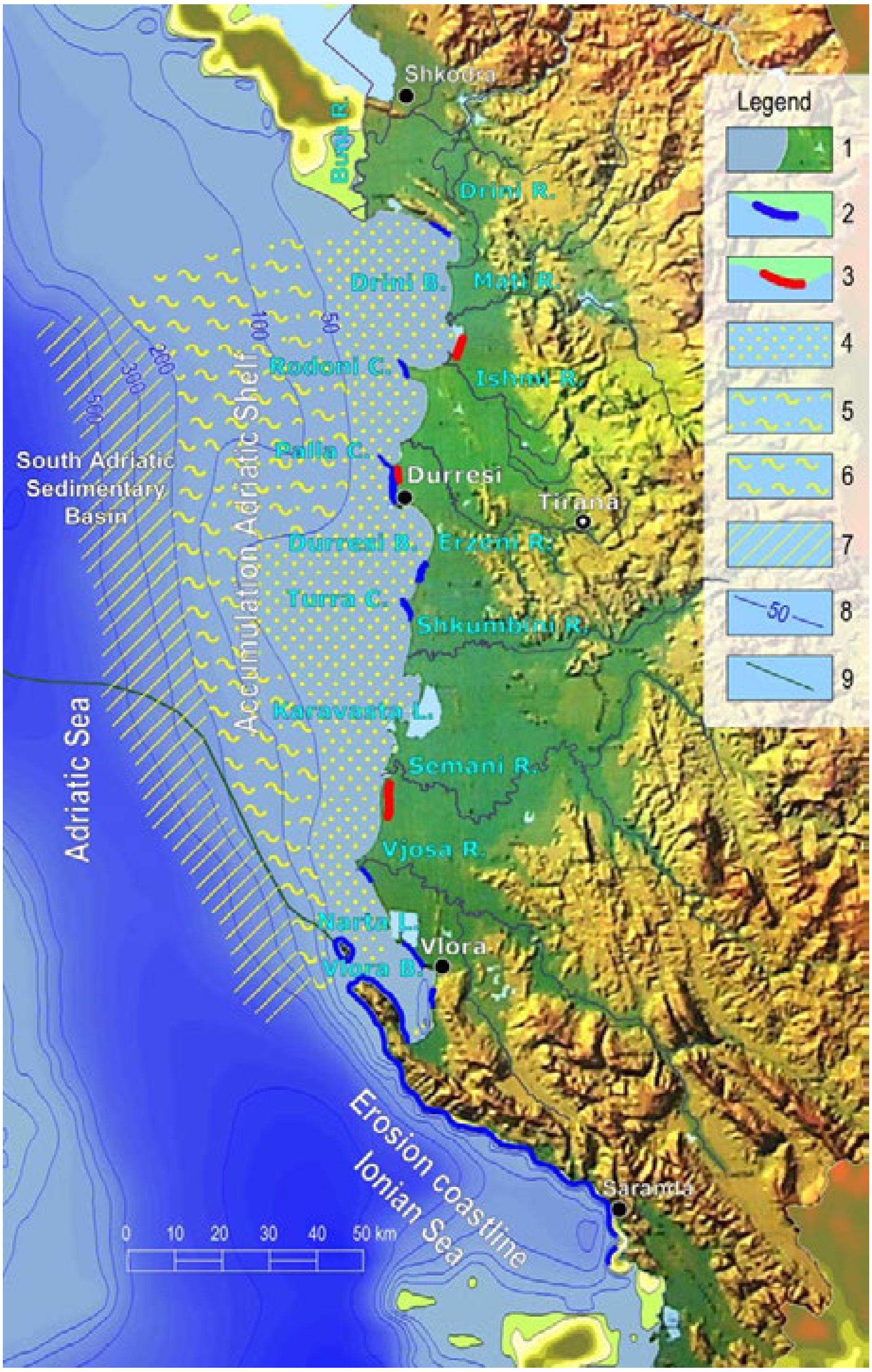

Fig. 2. Geomorphological Scheme of Albanian Adriatic and Ionian Seas coastline.

(Digital Terrain Model, National Geophysical Data Center (NGDC), Geodas database, 2005.

1- Accumulative coastline; 2- Erosion coastline; 3- Submerged littoral zone; 4- Shoal shelf area with sand deposits; 5- Flat shelf area with sandy-silt deposits; 6- Inclined shelf area with muddy silt and deposits; 7- Continental slope with argillaceous sediments; 8- Isobaths; 9- Western flank of the South Adriatic Sedimentary Basin.

3.1. Adriatic coastline

Adriatic coastline is lies over the Neogene Peri-Adriatic Depression, covered by Quaternary deposits, in western plain areas of Albania (Fig. 3, 4, 5). Flattened accumulative coast is general characteristic of this coastline. There are also some hilly marine caps with cliffed coast. The caps are located in the sectors where the Neogene structure of the Peri-Adriatic Depression are abrupt by coastline and continues in the Adriatic Sea, old river deltas or mouths and submarine coastal bar.

Adriatic coastline is divided in different characteristics zones:

1) Mouth of Buna River at the north to Rodoni Cap coastline. This unit has a length about 60 km and consists for almost 90% of beaches fed by fluvial imputes. The remaining 10% is clifts. Four rivers outflow within this area: from north to south Buna, Drini, Mati and Ishmi rivers All together they discharge on average 796 m^3/sec of water. The total solid load of the last three rivers is about 21,680x110^3 tons/year. Intensive change dynamics were observed in this area (Pano N. 1998).

2) Rodoni Cap, Durrësi Bay up to Shkumbin River mouth coastline. Cape Pallës, Cape Selitës, Lalëzi Bay, Durrësi Bay and Shkumbini River mouth are main sectors of this littoral area. Lalëzi Bay has a length of coastal line of 32 km, and 65% consists of sandy beaches fed by the sediment load of Erzeni River. The remaining 35% consists of rocky cliffs. Durrësi Bay has a length of 35 km from Pallës Cap to the Selitës Cap. Main part of the bay littoral, about the 54% of their length, by sandy beaches is presented. Frequently, with dune ridges, vegetate by pine trees, there are extended. Sediment inputs in to the bay are provided by Darçi River and from beach and cliff erosion.

3) Shkumbin-Seman-Vjosa rivers mouths up to Zvërneci hills coastline, is located in southern part of Central Albania, and have 40 km length. It expands in the western part of Ardenica and Divjaka hills (Photo 1). Karavasta Bay and Karavasta Lagoon are also part of this littoral area. From the geological viewpoint, this territory represents a new soil, constituted at the end of Pliocene and during Quaternary. The coastline in this region has a very intensive dynamics.

4) Vlora *Bay,* is represented southeastern edge of Otranto Strait (Photo 2) (Fig. 6, 7). The *Upper* Cretaceous- Triassic limestone mountains are encircled southwestern and southeastern shores of the bay. In the north, the mountain chain is continued with Neogene's deposits hills. Limestone coast of the Adriatic Sea in Vlora Bay is generally abrupt. At the northwestern direction of the Vlora City, there is a coastline of the Albanian Adriatic Shelf. Configuration the Vlora Bay has started to form from the Pliocene age, when the molasses of the Panaja Hills have been outcropped at surface (Fig. 6-b). Actually, Later Quaternary Marine deposits (Q_4^m) are created the present Vlora Bay (Fig. 6-a). Offshore these deposits (Q_4^m), according to the marine electrical soundings and boreholes, have 190 m thick (Fig.7).

Vlora Bay has a length of 36 km and 10 km width (Fig. 8). The maximal depth of this bay is 57 m. The coastline of Vlora Bay-Vjosa River Mouth area has continuously modified its configuration by sedimentation of alluvium transported by Vjosa River water and the swell of the Adriatic Sea. The coastal area is characterized by prevalence of winds blowing from the NW direction with a maximal speed 35-45 m/sec. The tidal range in this part of Adriatic Sea is low, reaching a maximum of 30-50 cm. The wave action is characterized by calm in 35% of the cases, by wave with a higher of less than 0.5 m in 20% of cases and waves higher than 2.00 m in 3% of cases.

Fig. 3. General Geomorphological Evolution view of the Vjosa River Mouth- Mati River Mouth in the Albanian Adriatic Littoral. (Geologic Map of Albania, at scale 1:200.000, 1983, the neotectonics active reverse faults & thrusts after Aliaj Sh. et al. 2000).

1- Alluvium Quaternary Deposits; 2- Marine Quaternary deposits; 3- Boggy Quaternary Deposits; 4- Pliocene Rogozhina conglomerate suite; 5- Pliocene Helmësi suite; 6- Neotectonics active reverse fault & thrust; 7- Coastal erosion; 8- Accumulative area; 9- Submerged littoral area; 10- Marine Electrical Sounding center.

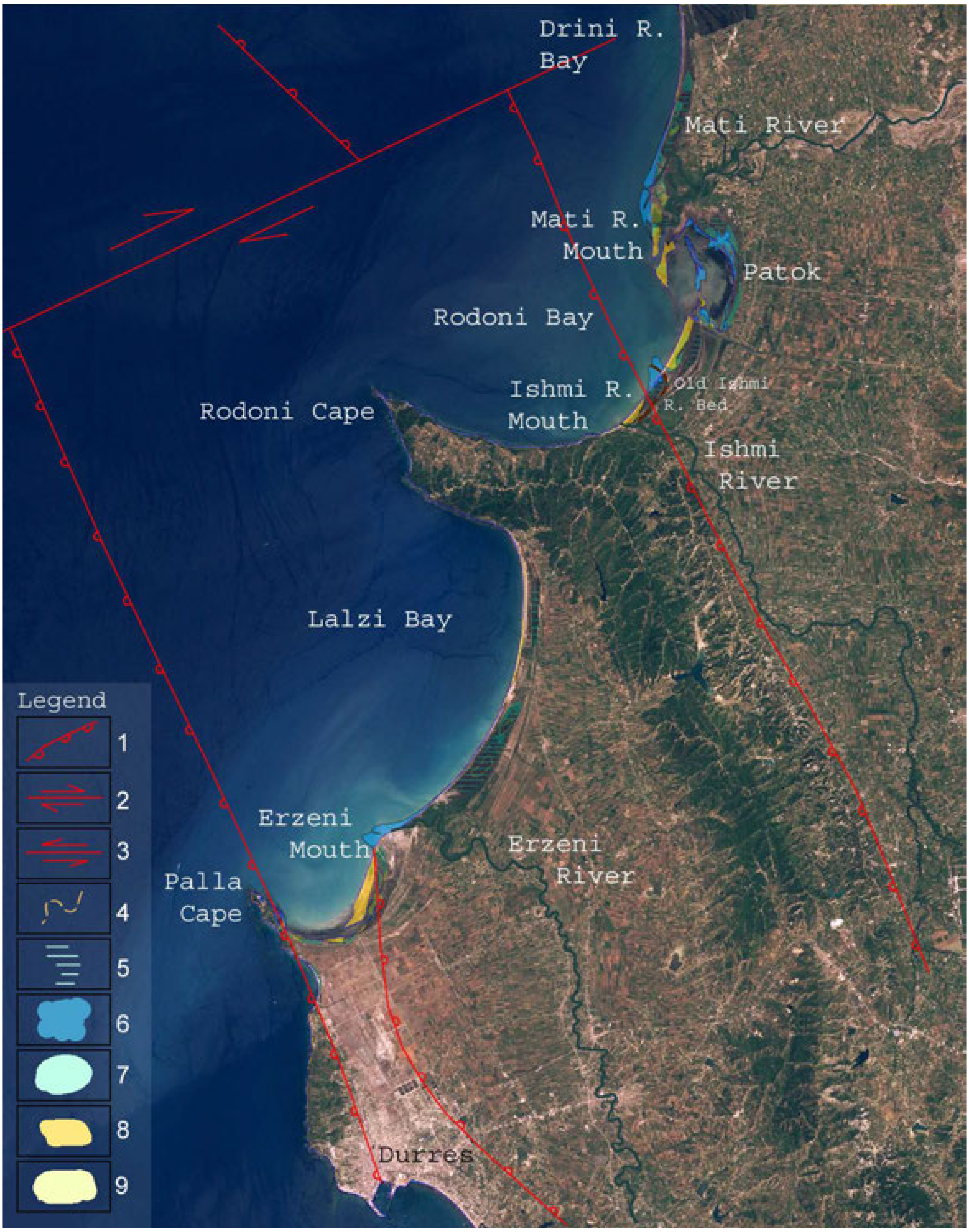

Fig. 4. Geomorphological Evolution view of the Drini Bay-Durrësi Bay coastline in the Albanian Adriatic Littoral after satellite images of the period summer 1977 & 2002 (Global Land Cover Facility Landsat, 2005; the neotectonics active reverse faults & thrusts (after Aliaj Sh. et al. 2000).

1- Active reverse fault & thrust; 2- Dextral strike-slip; 3- Sinistral strike-slip; 4- Old Mati River bed; 5- Wetlands; 6- Erosion and marine ingression; 7- Lagoon extension; 8- Coastal deposition; 9- Lagoon surface diminishing.

Fig. 5. Geomorphologic view of Shkumbini River-Vjosa River mouths coastline after satellite images of the period August 1981 & July 1989 & October 2001 (Global Land Cover Facility Landsat, 2005; the neotectonics active reverse faults & thrusts (after Aliaj Sh. et al. 2000).

1- Active reverse fault & thrust; 2- Dextral strike-slip; 3- Sinistral strike-slip; 4- Old Shkumbini River bed; 5- Coastal deposition with predecessor erosion; 6- Coastal deposition; 7- Coastal erosion; 8- Submerged littoral area.

3.2. Ionian coastline

5. Karaburun to Saranda Bay coastline represents Albanian Riviera (Fig. 1, 2). Mostly erosive coastline is lies along 112km of Lower-Upper Jurassic and Upper Cretaceous limestone, and Oligocene flysch formation piedmonts. There are predominating emerged coast and estuary coast in some sectors of streams. High mountains rise up to 2045 m, immerged coast and very clear marine blue water are presented a very beautiful area. Cliffed coast by outcropped limestone layers are characterized western side of the caps. In the beautiful along the some sectors of the coastline are lies, mostly Quaternary proluvial, gravel beaches.

6. Butrinti Bay: An accumulative coastline from Butrinti Lagoon channel to the Pavlë River mouth represents southern edge of the Albanian Ionian littoral. It is western edge of the Vrina field, where flow Pavlë River that has a 6.51 m^3/sec averagely water yearly discharge to the Ionian Sea.

3.3. Outlook on Albanian Littoral hydrology

The water flow of the hydrographic network of the Albanian rivers to the seas varies in wide limits. The discharge of the Albanian rivers into the Mediterranean Basin varies in very wide limits, from Q_o=700-850 m^3/s for the hydrological years of a lower precipitation to Q_o=1850 2150 m^3/s for the years of a higher precipitation. The volume of suspended material, which is transported through river network, is 65,7. 10^6 ton/year, while the turbidity Q_o=1 260 g/m^3 (Pano N. 1984).

The river suspended matter deposits itself the river mouth in the Adriatic Sea. This process is very dynamic, making the Albanian river's mouths very active. Many changes of the riverbeds position formation of the coastal lagoon, etc. are observed time after time in these mouths. The wind regimes, wave refraction, sea currents, littoral sediment transport, have determined the general dynamics of the change of the Albanian coastline (Pano N. 1994). The period with the wave height of H_l=(0,1-0,2)m represents about 80% of the general cases, while the height of H=(0.2-4.5)m about 20% of them for the average multi annual year. The highest waves have a direction from Northwest to West and a maximum wave height about h=3.5-4.5 meters near shore (Pano N. et al. 1974, Meçe B. 1978). Sea level has an average daily amplitude 0,30-0,40 meters and a multi annual maximal amplitude h=1,14-1,53 meters.

The winds in the Adriatic Sea change their direction and speed during a year period as a result of the typical Mediterranean climate. Intensive winds with their maximal speed of 40 – 45m/s particular of NW, W and SW direction were observed in the coastal area. Winds with varying speed form 10 to 20 m/s, have a bigger frequency on waving process. The average annual temperature of the water varies from t=17,7°C in Shëngjini to 19,2°C in Saranda bays (Albanian Climate (Tables), 1978, Mici A. etc. 1975).

4. Geological settings of the Albanides littoral

The Albanides represents the assemblage of the geological structures in the territory of Albania form the southern branch of the Mediterranean Alpine Belt. The Albanides are formed by two major palaeogeographic domains: the *Internal Albanides* in the eastern part and the *External Albanides* in the western part of Albania. The Internal Albanides are characterized by the presence of the immense and intensively tectonised ophiolitic belt. The External Albanides developed on the western passive margin and continental shelf of the Adriatic plate (Fig. 1).

Albanian Adriatic Littoral area is located in Albanian Sedimentary Basin, which extends widely into the Adriatic Sea (Fig. 1, 3) (Aliaj Sh. 1989, Frasheri A. 1991, Leci V. et al. 1986, Papa A. 1985). Towards the East, in the mainland, Albanian sedimentary basin is

superposed to the western board of Albanides orogen. In Adriatic shelf, this basin is superposed to the Pliocene-Quaternary platform, which has a basin facies. Albanian sedimentary basin represents a foredeep depression filled with Miocene and Pliocene molasses, and covered by Quaternary deposits (Geological Map of Albanian, 1984). Sandstone-clay Serravalian (N_1^{2s}) deposits transgressively overlies older layers. Tortonian and Messinian sections are represented by sandstone and clay. Pliocene deposits consist of clay and sandstone conglomerate.

Quaternary deposits (Q) at Albanian Adriatic littoral are represented by different genetic types: -clay-silt-sand of marine deposits, which have a thickness which ranges up to 200 meters in the Albanian Adriatic littoral areas. Marine Quaternary suite is composed by gray-yellow silty-clay, clay and quartzose fine-coarse sand, and in any case with heterogeneous dispersed small granule. The Albanian Adriatic coastline has many beautiful sandy beaches. These beaches have different geomorphology, depend on the geology and tectonics of the area. There are located also lagoons and coastal marsh deposits, and alluvial deposits.

Sea-floor geomorphology, the distance from shores, the marine currents, the wave process, the shore lithology and geomorphology, the erosion and accumulation processes, have determined the distribution of the Adriatic Sea floor Quaternary sediments:

In Adriatic Sea Shelf are located some molasses Neogene asymmetric anticlines. The Neogene geological structures of the Peri-Adriatic Depression continued from mainland to the Albanian Adriatic shelf for 5-10 km.

Evolution of Albanian Adriatic coastline has a very intensive dynamics. There is observed old and present shoreline migration up to 5-10 m/year, during the period from 1918 up to 1998. According to submarine geological mapping and geoelectrical survey data, has been determined that marine deep erosion is developed in accumulation littoral of Adriatic shoal. The sandstone banks have been mapped in western submarine anticline limbs.

The Ionian Sea littoral is represented western edge of the Çika anticline belt in Ionian tectonic zone (Io). This zone occurs the southwestern part of Albania and developed in a deep pelagic environment the Upper Triassic. The Permian-Triassic evaporites are the oldest rocks in this zone. Overlying are thick deposits formed by Upper Triassic-lower Jurassic dolomitic limestone and Jurassic-Cretaceous-Palaeogene pelagic cherty limestone. The limestones are overlain by Palaeogenic flysch, an Aquitanian flyschoidal formation and a thin section of Burdigalian-Langhian. Structures are fractured by longitudinal tectonic faults on their western flanks, with thrusting of 5-10 km horizontal displacement.

Paleomagnetic studies have demonstrated that assemblage of the Albanides margin has supported a clockwise rotation with amplitude about 45°, after upper Oligocene. Shkoder-Peje transversal is represented a transition zone between the clockwise rotation of the Albanides and Hellenides and counterclockwise of the Dinarides. Horizontal displacement is about 173 km in southern Albania, for the rotation pole located at Shkoder-Peje transversal. This palaeorotation have important influence on Adriatic Sea morphology.

Geomorphological processes have determined the sea floor topography. Consequently, bathymetric configuration of Albanian Adriatic coastline is similar to the geomorphological configuration.

5. Analyze and results

5.1. Albanian Adriatic Sea Littoral and Quaternary Evolution

Adriatic coastal line from southern city Vlora up to Shëngjini Bay, in the north, have the marine accumulation flattened littoral, the marine erosion coast, and the submerged areas, where is observed marine insgression toward the mainland. In some areas there is cliffed coastline.

5.1.1 .Accumulative areas represents main part of the coastline

Accumulative areas of the Albanian Adriatic Sea Littoral are extended over the edge of western Albanian plains (Photo 1). This littoral is characterized by presence of the different Quaternary (Q) deposits genetic types (Frasheri A. 1961, Frasheri A.et al 1991, Leci V. et al. 1986, Ostrosi 1977):

Marine Quaternary littoral deposits, presented by fine, medium, and coarse gray—white, gray-yellow sand, silty clay and mud interbeds present marine Quaternary littoral deposits. Interbeds thickness varies from 1-10-15 meters. Present days micro and macrofauna of seawaters comes across everywhere (Photo 3).

Very beautiful sandy beaches are extended in Drini, Lalezi, and Durrësi bays, Divjaka, Semani and Vjosa River mouths and at the Vlora Bay (Photo 4, 5). Present time shore sand knolls have a length up to 4-5 km, width 35-80 m and some meters highs. At the northern bays, the coarse sand is predominated. Toward the southern part of Adriatic coastal line, fine and medium sand are predominated. This sand belt are composed by two or three parallel onshore dunes: the first dune is extended directly at the water line, the second at the distance 90-100 m and the third dune 150-200 m. There are concentrated placers of heavy rare and precious minerals (Photo 6). Placers lens have a western dipping with an angle about 5-10^{o}.
According to the integrated marine geological-geophysical surveys, in the shore shoal zone, which represents a flat depression up to –50m depths, the Pleistocene up to actually Quaternary sand and sandy silt sediments were distributed, under the waves process and marine currents (Fig. 2) (Leci V. et al. 1986, Papa A. 1985). Towards the flat shelf depression, up to –100m depths, the sandy-silt sediments are representative. In inclined shelf area, up to –200 m depths where are also some submarine hillocks, the muddy silt deposits are distributed. Continental slope by argillaceous sediments is characterized. Lithological changes from the shore to the continental slope area are gradually. There are observed some peculiarities, of river solid load distribution in shelf area, conditioned by marine currents. Typical is "Black sand" zone that is located about 40 km from shore, at the sea depth about 100m. The actually sand sediments have formed a low submarine hillock, where has been old Shkumbini River Mouth (Papa A. 1985). Up to continental slope at the west of the Albanian Adriatic Shelf zone, were observed sand load, which have been transported by marine currents (Pigorini B., 1969). Epidote and other heavy minerals have contented in this load, which are demonstrated that have an origin from ophiolitic Albanides Belt.

The maximal thickness of the Marine Quaternary deposits is observed at the central part of the marine bays, according to the marine electrical soundings and mapping boreholes data (Frashëri A. 1987, Leci V. et al. 1986). In the fig. 6 is presented the thickness map of the Quaternary marine deposits in the Durresi Bay. The maximal thickness is 48m at the central zone of the bay, about 6 km south of the Durrësi city. Toward the sea depth, the thickness is increased by a gradient 4.5-12 m/km. In the fig. 9 is presented the thickness map of the Quaternary marine deposits in the Vlora Bay, at the western of the Zvërneci area, about 2.4 km from the coastline. In this sector, the Quaternary thickness varies from 65-180 m (Fig. 7). At the marine electrical sounding centers and the deep wells Seman-1 and Seman-3 in mainland of the Semani area shelf, the thickness varies 50m up to 200m.

Buried sand knolls are situated along littoral belt at the mainland. Sandy littoral belt along the accumulative littoral have a width up to 5 km (Photo 7). Sand dunes belts have a length of 25 km. Dunes have a length 2-5-6 km and an average width more of 50-100 m.

Generally, the granulometry of quartzite sand deposits represented by very fine up to medium sand. Thickness of the sand dunes is some meters (2-10 m). Under the sand, the silty-clay or clay layers are located, with a thickness some meters. In many sections, the fine, polymictic, gray sand lays under the clay, which have a thickness more than 10 meters. Loose

sand in the coastal line and clay mud is layered far from coastline lagoons and coastal marsh deposits. These deposits are presented by thin alteration of compact clays, silt-clays and silt beds, with vegetable debris and blue-gray fine organic mater, and saline water macrofauna. These entire Holocene marine deposits layers lies horizontally or with small western dip angle, 7-8^{o} (Photo 6). Alluvial deposits and clayey earth are layered far from the coastline.

Filling process is intensive, generally, in river mouths.

In these accumulative coastline areas there are some relatively small erosion sectors, which are located at the Mati, Erzeni, Shkumbini, Ishmi and Vjosa river mouths. Typical is shore erosion that developed by Darçi River flow in Golemi-Karpen beach sector in the Durrësi Bay, with an erosion rate of 0.5 m/year.

In the shoal shelf zone, at the alluvial sea floor are observed the sandy splits. Typical is a submarine bar, which has been formed by solid load discharged by Buna River in Drini Bay. This split is extended up to Drini River Mouth.

5.1.2 .Erosive zones

Marine deep erosion zones were developed over some sectors in accumulation littoral of Adriatic shoal. These zones are located in the uplifted side of the active reverse fault & thrust (Fig. 3, 4, 5).

The Rodoni, Palla, Selita and Zvërneci capes of the molasses bedrocks of the littoral anticlines of the Periadriatic Depressions have represented the erosion configurations of the Albanian Adriatic sea coastline.

Rodoni Cape. Erosive area is located at the western and northern part of the Cape. Tortonian sandstone-clay banks have been mapped in Adriatic shelf over these sectors.

Durrësi–Pallë Cape area is one most typical erosive segment of the Albanian Adriatic littoral. Durrës-Kepi Pallës coastline is extended along the western flank of the Miocene-Pliocene molasses anticline. Northern pericline and western fold flank are lies under the Adriatic Sea waters. The structure is asymmetric and eastern flank is tectonically abrupt. Anticline top is located under the seawater, about 1600 m at the west of the shoreline. Molasse deposits are covered by different kinds of the Quaternary loose deposits. Seashore is abrupt and the sandstone banks have been mapped in western submarine anticline limbs . The sea-floor sandy belt, of 2.5 km width, which lies parallel to the coastline in the shoal zone. According to the integrated marine geological-geoelectrical surveys there are observed, submarine Miocene-Pliocene bedrock banks (Photo 8, Fig. 10, 11 (Frasheri A. 1977, Leci V. et al. 1986, Papa A. 1985).

Geodynamics of the coastline is demonstrated also by historical and old shoreline migration. At erosional Currila sector, northern of Durresi city was observed an ingression of the shore during post Alerodiane glacier period and later up to present coastline location. Marine geological surveys have observed gravel and coarse sands under 20 m thick a silty-clay layer, and 20 m sea depth, at 2 km from the shore. Gravel and sand transgressively have covered the Tortonian bedrocks (Leci V. et al. 1986, Papa A. 1985). These depositions are represented Pleistocene old shore. Generally, Durresi coastline has an ingression averagely of 2 km during the Pleistocene. There are observed also some archeological objects covered by seawaters in Currila zone.

Selita Cape, in the northern edge of the Kryevidhi Pliocene Hills.

Zvërneci hilly zone is located at northwestern direction of Vlora city (Fig. 2, 8). The old sand split from Vjosa River mouth to the northern edge of the Zvërneci Tortonian hills and these hilly chain separated Narta lagoon from the Adriatic Sea. The southward shift of the Vjosa River mouth during the XX century has created serious erosion problems in the northern coast of the Narta lagoon. The sediments input to the old delta ceased, the latter has almost been completely eroded and the sediment was removed to create a split, which formed

an accumulative zone in the southern part of the Vjosa River old mouth (Fig. 8) (Thereska J. 1981).

In the Rodoni, Selite and Zverneci caps of the shoal shelf zone, are observed the same sea floor morphology and sediments that in thje Durresi-Palla Cape zone, with many bedrocks submarine banks.

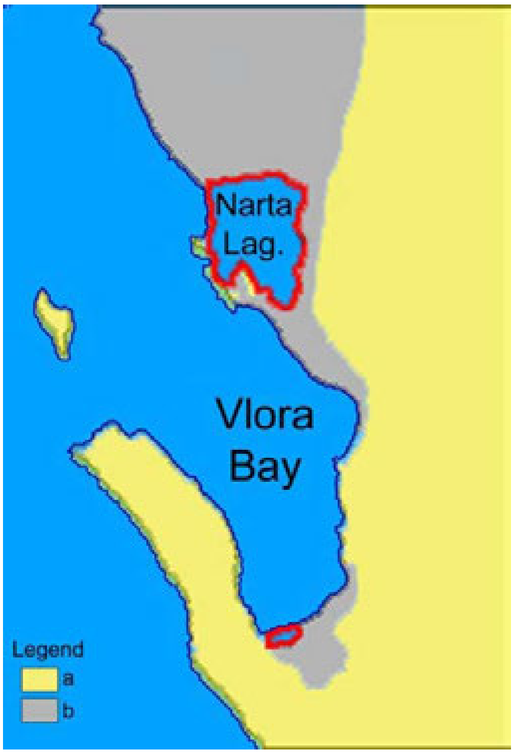

Fig. 6. Paleogeographic evolution of the Vlora Bay from end of Pliocene Age (a) up to Present days (b).

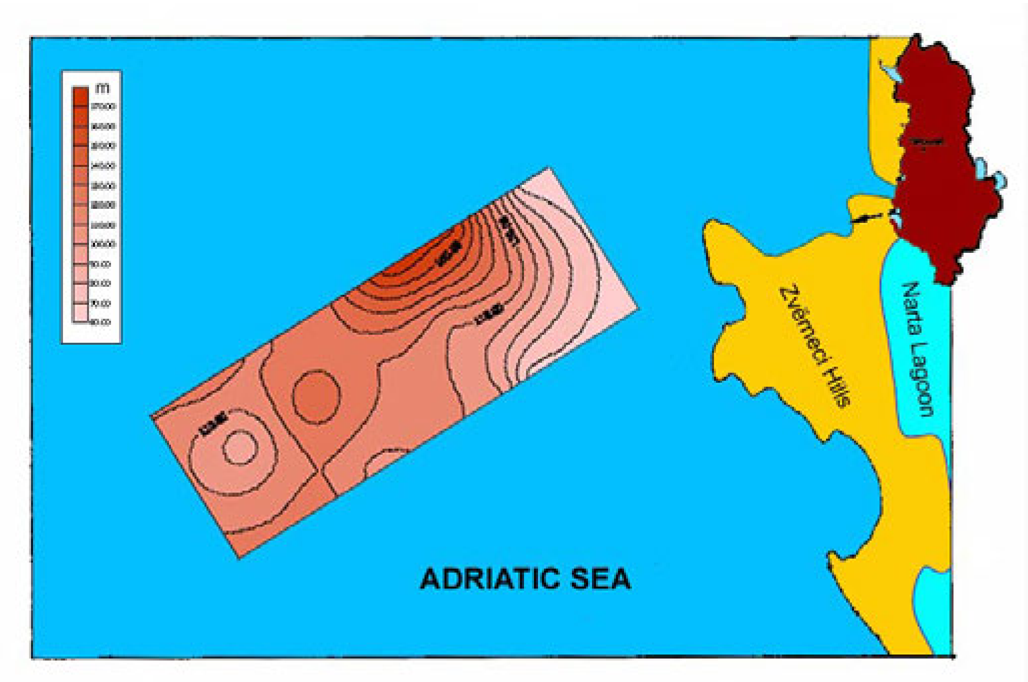

Fig. 7 Thickness Map of Quaternary Deposits in Vlora Bay, at Zvërneci area, according to the Marine electrical soundings.

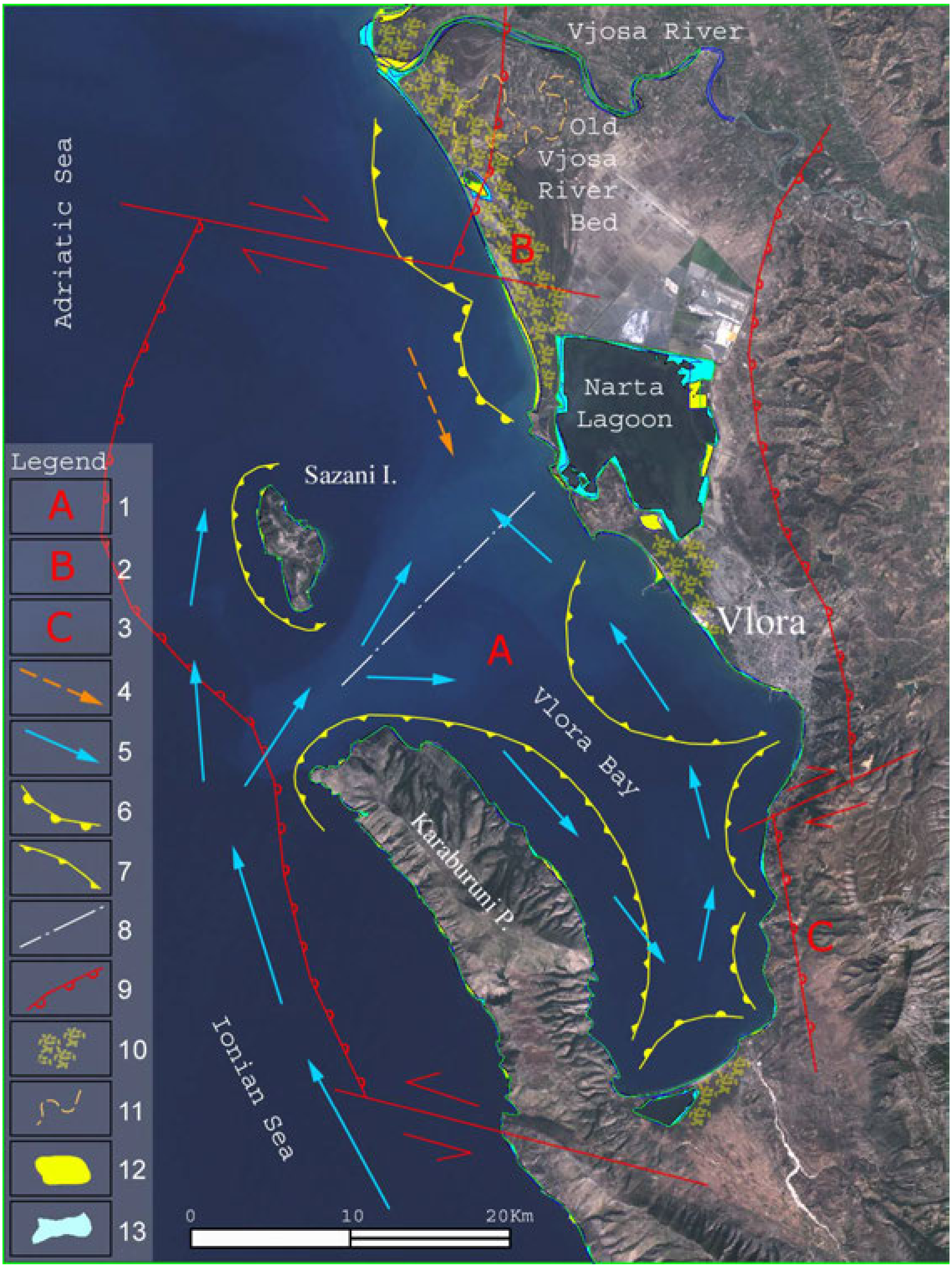

Fig. 8. General Evolution view of the Vlora Bay after satellite images of the period August 1981-July 1989-October 2001 (Global Land Cover Facility Landsat, 2005; Neotectonics active reverse faults & thrusts (after Aliaj Sh. et al. 2000).
1- Marine shoal with sand deposits; 2- Littoral with sand beaches; 3- Rocky coastline; 4- Alluvium flow; 5- Marine current direction; 6- Accumulation area; 7- Erosion area; 8- Southern edge of the sediment replacement; 9- Active reverse fault & thrust; 10- Sand; 11- Old Vjosa River bed; 12- Filling coastline; 13- Erosion coastline.

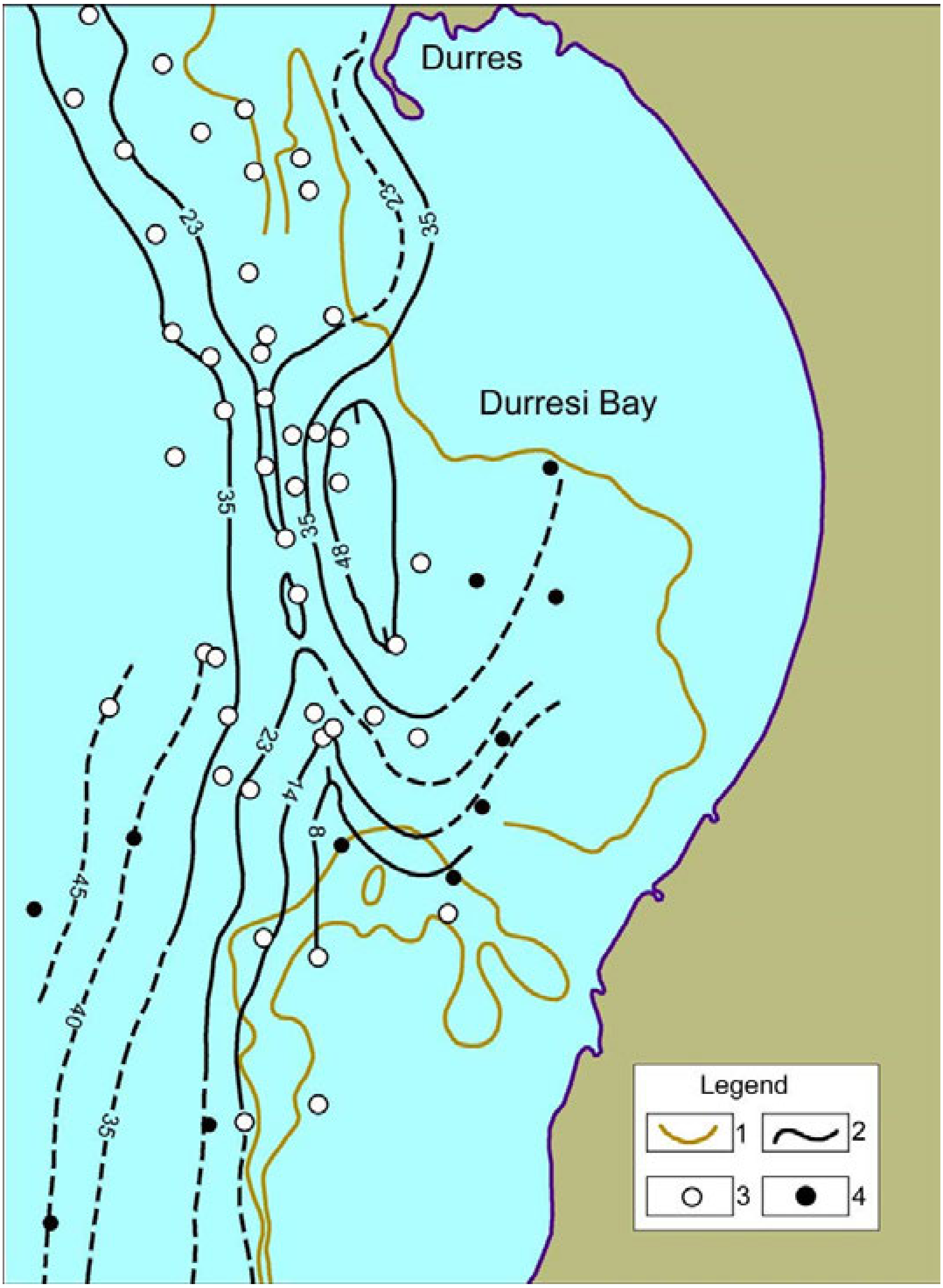

Fig. 9. Thickness Map of Quaternary Deposits in Durrësi Bay, according to the marine electrical soundings.

1- Boundary of distribution of sand-argillaceous sediments; 2- Contours of the Quaternary deposits thickness; 3- Marine mapping boreholes; 4- Marine electrical sounding centers.

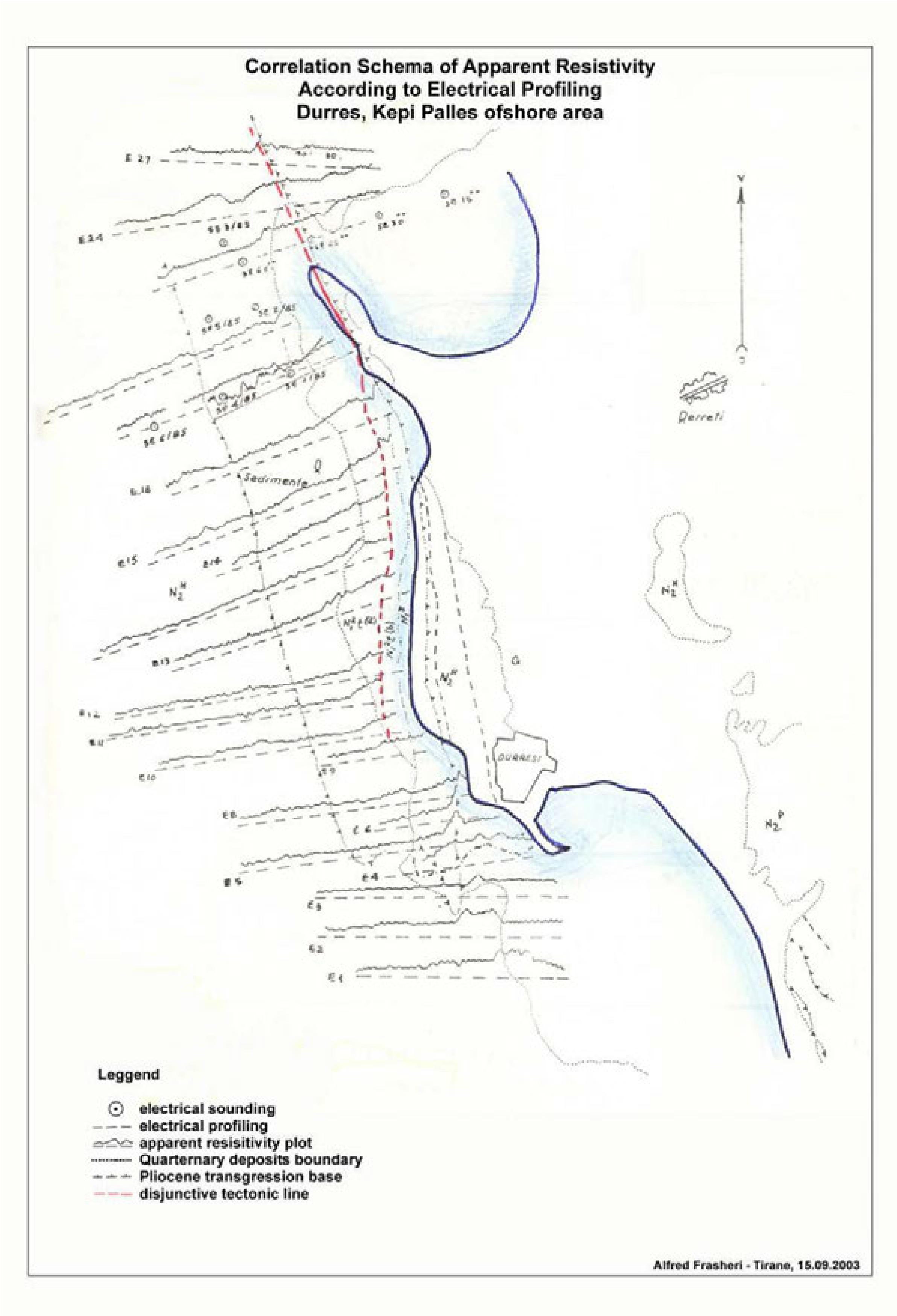

Fig. 10. Correlative Schema of Apparetnt Resistivity according to the Marine Electrrical Profiling, offshore erosive littoral at Durrësi-Kepi Pallës area.

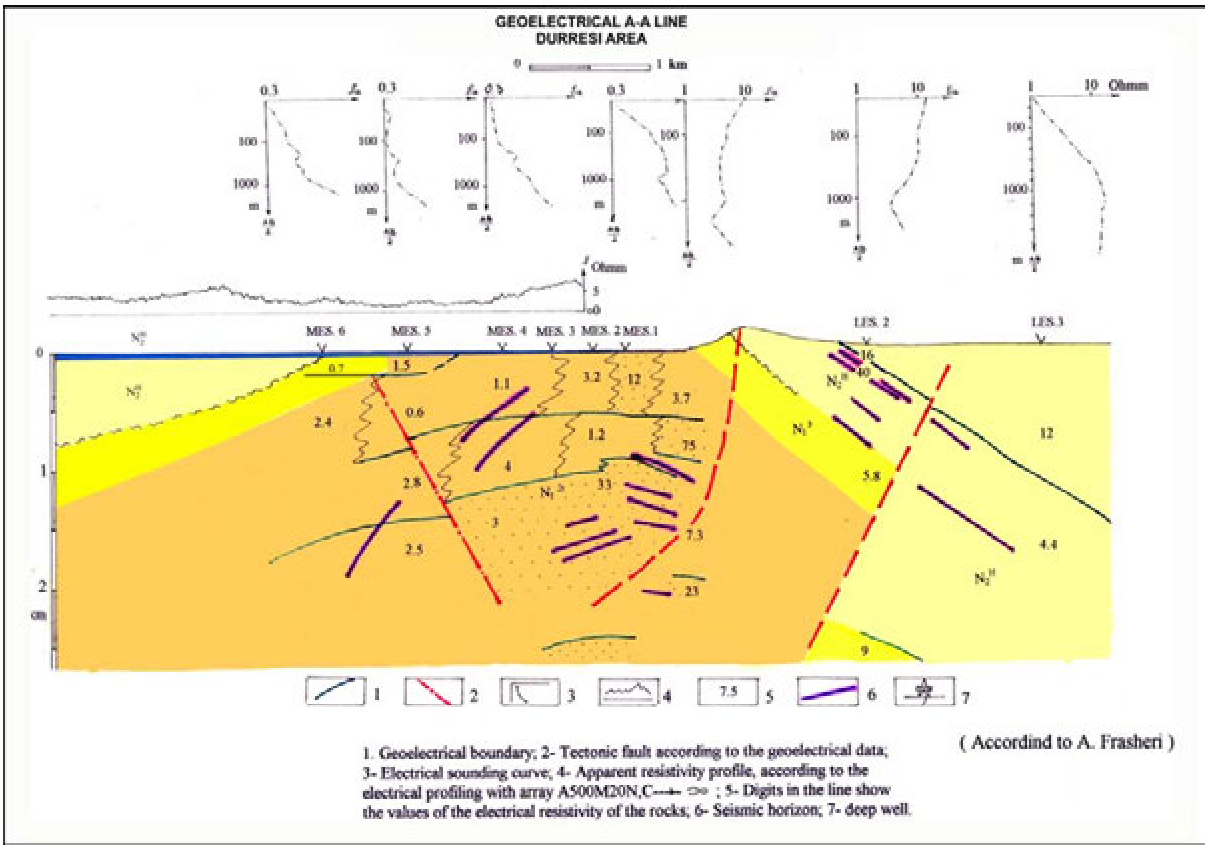

Fig. 11. Geoelectrical Line, erosive littoral at Durrës-Kepi Pallës area.

1- Geoelectrical boundary; 2- Tectonic fault according to the geoelectrical data; 3- Electrical sounding curve; 4- Apparent resistivity profile, according to the electrical profiling with array A500M20N, C→∞; 5- Digits in the line show the electrical resistivity values od the rocks; 6- Seismic reflector.

5.1.3 .Submerged areas, where is observed marine transgression toward the mainland

Semani beach at western Albanian region and Patoku beach in the southern side of the Shwngjini Bay represent submerged areas within accumulative coastline. Submerged process is caused by the neotectonics activity, consequently there are observed a marine transgression.

Re-activation of the disjunctive tectonics at the littoral area Vjosa River mouth to mati River mouth is observed. In the littoral segment Seman beach - Karavasta Lagoon -Shkumbini River mouth, in the both flanks of the Semani asymmetric anticline structure the disjunctive tectonics, with small amplitudes of 200-400m, are reactivated. According to the neotectonics studies, an active reversed fault with western thrust direction, from Vjosa River Mouth to south of the Semani River Mouth, is laid in the mainland, parallel with the coast (Fig. 3) (Aliaj Sh. 1998, 2000, Aliaj Sh. et al. 2000). According to the marine electrical resistivity tomography, performed by marine electrical soundings, the morphology of the marine Quaternary loose deposits has a horizontal layering (Fig. 12) at the western side of the Semani beach. In south and east northern sides of the geoelectrical line is observed reversed fault impact. Consequently, the Semani sandy beach, which is located at western side of this fault, in the submerged process, is found, from 4 km of south of the Semani River Mouth up to Semani Beach area, in the about 10 km long segment (Fig. 3, 5). So many objects that 20-35 years ago have been constructed in the mainland, at the present under the seawaters are found, ex. the Seman-3 deep oil and gas well basement (Photo 9). Semani-3 well has been drilled in

1969 in the mainland, 265m from the coastline. During the period 1969-1983 coast water line has a ingression of 135 m toward the mainland, with a gradient 9.4 m/year. From 1983 up to 2004 the ingression has amplitude 170 m, with a gradient 8.1 m/y. In this are, submerged process was started about 160 years ago. There are some small sectors, with a length about 4km, where the marine waters for about 2.5-3 km in the mainland are seeped.

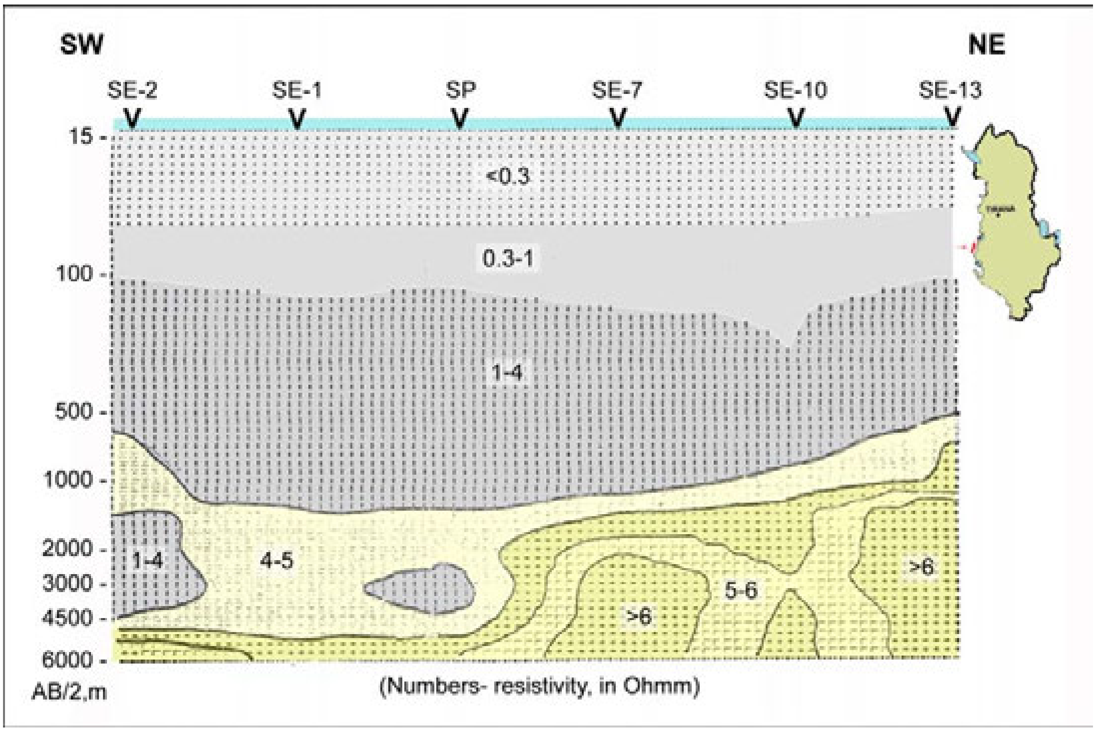

Fig. 12. Marine Electrical Resistivity Tomography Line, Semani Adriatic Shelf.

In fig. 5 can observed that submerged process is not developed in same time along all length of active reverse fault & thrust line. Toward the Vjosa River Mouth, is not observed such intensive submerged process that in the Semani Beach.

Uplifted side of the reverse fault & thrust, at northeastern Semani River Mouth-Karavasta Lagoon and Shkumbini River Mouth, under the neotectonics uplift process is found. There are observed marine regression.

Second submerged are at the Adriatic littoral is observed at the Patoku beach, between Ishmi River Mouth at the south and Mati River Mouth at the north (Fig. 3, 4). This area is located at northern direction of the Rodoni Cape. This submerged area has more complicated development. In 1972, the sand beach there has a width about 175m. In 1982, the width of the beach only 100m was. Actually, beach hotels and other buildings, under seawaters are found (Photo 10). Patoku beach area is located at submerged side of the active reversed fault with eastern thrust direction. This fault is located in lowered wall of the Neogene molasses of Rodoni monocline (Fig. 3). Uplifted side of the reverse fault & thrust, at southwestern direction is found, between the Ishmi River Mouth, southern of the Patoku beach, and Rodoni Hills.

Small submerged area in the Porto Romano area is observed, too, which is located between Durrësi City and Palla Cape.

In the submerged zone are observed integrated factors of the coastline evolution: neotectonic, erosion by marine currents and accumulation of the solid river discharge and eroded shore sediments. This factors complex has caused important changes on the coastline geomorphology, marine shoal and littoral landscape. Typical are Patoku and Semani area. Submergence in Patoku area has caused replacement of the Mati River Mouth towards the south, start from the 1978 year. From the 1982 year, the river solid discharge has started to form sand split, from the mouth up to 300 in southeast direction (Fig. 4). According to the satellite images of 2000 year, this bank has been with a length about 1400 m and has been emerged over the sea surface. In 2005, this sand slit has a length over 2 km and is covered by dense vegetation (Photo 11).

5.1.4 .Lagoon area

Lagoons have a total surface of about 150 $km^{2,}$ while the volume over 350-million m^3 water. Albanian lagoons represent crypto-depressions, with the floor under the level of the sea's bottom. The lagoons represent the new lakes. Its creation started during Pliocene Period, some 4-5 million years ago, and its creation lasted during the Quaternary Era till our days. The neotectonic phenomena also characterize the lagoon area.

Karavasta Lagoon, is the biggest and the most important lagoon system on the Albanian coastal area. It is located between the mouths of Shkumbini River (in the north) and Seman River (in the South). Lagoon has a surface of 43,3 km^2, with a maximal depth of 1.5m. It communicates with the Adriatic Sea through three short channels (Pano N. et al. 2004). They were created during the closing of old marine bays by sandy belts as results of the accumulation of solid discharge of Semani and Shkumbini Rivers.

New split is formed in Karavasta Bay, which has formed Karavasta Godulla.

Narta Lagoon, is situated in the northern part of the Vlora Bay, about 3 km from Vlora City. Narta Lagoon has a surface of 41.8 km^2, the maximum depth 1.5 m and the average depth is 0.7 m. (Photo 11) (Pano N. 1983). Lagoon was formed in a sea bay, which is closed by solid sediments transported by Vjosa River to the sea. Old Zverneci split bar separated Narta lagoon and sea area.

Butrinti Area is located at southwestern part of Albania. This area represents most beautiful part of Albanian Ionian Rivera (Photo 12). The ancient Butrinti City has been built in this area. A chain of hills separates Butrinti Lake from Ionian Sea (Photo 13). Shores around these hills represent rocky and abrupt lakeside. Lake has a tectonic origin. It represents water filled graben.

5.2. Outlook on coastal evolution

Adriatic coastline has an intensive changes and continuously modifying its shape (Boçi S. 1981, Pano N. 1994, Simeoni U. et al. 1997, Shuitsky Yu. D. 1999).

There we are analysed three most representative areas:

Drini Bay. Intensive change dynamics, Viluni Lagoon and Shëngjini portal town characterized this littoral area. The decreased sediment load of the Drini River, caused by its diversion into the Buna, has triggered coastal recession between Shëngjini and Tale, with greater intensity on the southern lobe of delta. Moving southwards, the coast becomes part of the sedimentary system of Mati River. The coastal area between Tale and Patok can be considered as having a positive sediment budget (Pano N. 1998).

Karavasta Bay. The Seman and Shkumbini rivers are the main source of coastal sediments in Karavasta Bay. The average water discharge is 62 m^3/s. The average annual water discharge of the Semani River (Q_o) to the Adriatic Sea is 0.9m^3/s; and the annual load sediment discharges is R_o=399kg/s, which has a correlation with the water discharges-Q_o (in m^3s^{-1}) for

two main branches (Pano N. et al. 2003, 2004):

$$R_o=0,605.Q_o^{1.46} \quad \text{- for Osumi River, and}$$

$$R_{o.2}=0,219.Q_o^{1.69} \; ; \quad \text{- for Devolli River}$$

The total sediment discharge by this river to the Adriatic sea is W_T= 15,7.10^6tons/year. About 19% of total sediment load is equivalent to W_F=3,15.10^6 tons/year is carried bad load, and 81%, equivalent to W_F=12,6.10^6 ton/year, is suspended sediments. The wave highest in the Seman River mouth observed along the coastline, have a deep-water direction from the NW and the W and a maximum wave height of 4.0 m seashore. The dominant winds are southeasterly, easterly, and northwesterly winds. Maximum waves converge towards northeastern zone of coastline. This coastline corresponds to an extensive delta coast (microtidale: 0,50 tidal range) with a large alluvial plain of Myzeqe.

In ten last years, the coastline has advanced some hundred meters. Semani River mouth has changed in position in the last centuries six times and this displacements have covered on area of the littoral about 15-20 km long in a direction North-South; South-North during period 1870 to 1994 years. In these conditions in the coast area there are two important sources of coastal sediments: the actual rivers mouth and the olds rivers mouths (Fig. 13). The outlet of Semani River was shifted from position A and A_1, the old mouths, to the actual position B", that is up date position. The old mouths of this river (coastal area A' and coast A") is undergoing on important submerged process under the neotectonics activity and erosion from the wave action.

Vjosa River Mouth-Vlora Bay. The general evolution map of coastline in fig. 8 is presented (Pano N. 1994). Vjosa River Mouth has changed its position in the last century two times and these replacements have covered an area of the littoral about 10 km long in the northern direction. The old mouth of this river is undergoing on important erosion process under the wave action. There are two sources of coastal sediments: first, the present Vjosa River Mouth, and second the old Vjosa River Mouth.

5.3. A correlation between geological setting Adriatic Albanian Shelf and sea hydrology

Two Albanian Oceanographic Expedition "Saranda-1963" and "Patosi-1964", have presented data, which have argument that the total discharge of the Albanian rivers system in the Adriatic and Ionian Seas have a minimal discharge is 700-800 m^3/s during the hydrological dry years of low precipitation and maximal values 1900-2200 m^3/s during the hydrological wet years of high precipitation (Pano 1974, 1984, 1994). Buna River, together with Po River in Italy, is determinant in the water balance of the Adriatic Sea (Photo 14).

Ground surface history after geothermal inversion and meteorological data were observed a climate worming for about 1°C during the first half of XX century. Thirty quart of this century has been characterized by a cooling for 0.6°C. Later, up to present a worming for 1.2°C is observed (Frashëri A et al. 2004). The warming period in Albania is accompanied with changes of the rainfall regime, wind speed and wetness. There are observed a decreasing of the total year rainfall quantity, for about 200-400 mm. This warming is part of the global Earth warming during the second half of XX century. These climate changes have their impact on country water system, on and water resources, and in the erosion processes (Pano N. et al. 2004). Inland water resources change has its impact on the hydrographic regime of the Adriatic Sea (Frashëri A. and Pano N. 2003).

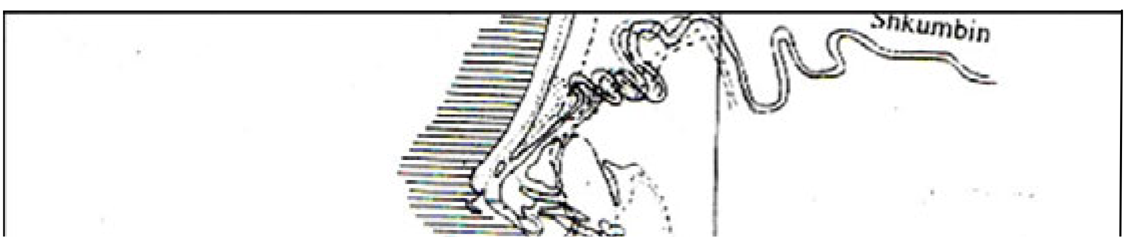

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Fig. 13. The general map of the evaluation of the coastline from 1870 to 1994 in the Semani-Karavasta area (A and A1–old river mouths; B'–actual river mouths; A A' A''–sources of coastal sediments; 1–marine currents; 2–wave processes; G–submersed area; K–accumulation area)

The oceanographically situation of the wet years 1963-1964 has been characterized by formation of "The Bridge" of low salt content and density, and higher temperatures of the seawaters in the Adriatic Sea. A higher surface water temperature in the Drini Bay is confirmed also by satellite observations, with a higher temperature of 3-4°C (Fig. 17) (Adriatic Sea Water Surface Temperature, restored from NOAA satellite data 19.08.2005).

. The "Bridge", includes surface water layer, and the Levant Intermediate Water (LIW) up to 600 m. depth. This phenomenon has a complex and an important influence on many dynamics aspects of the formation Adriatic Deep Water (ADW), and the monitoring mechanism of water into Otranto Street.

This "Bridge" is correlated with the heat flow density anomaly at the sea bottom (Geothermal Atlas of Europe, 1992) (Fig. 18). The "Bridge" direction is corresponds also with the prolongation into Adriatic Sea Albanian Shelf of well-known Scutary-Pec regional tectonic transversal over the Albanides, which is outcropped in Albanian mainland, with a SW dextral strike-slip direction.

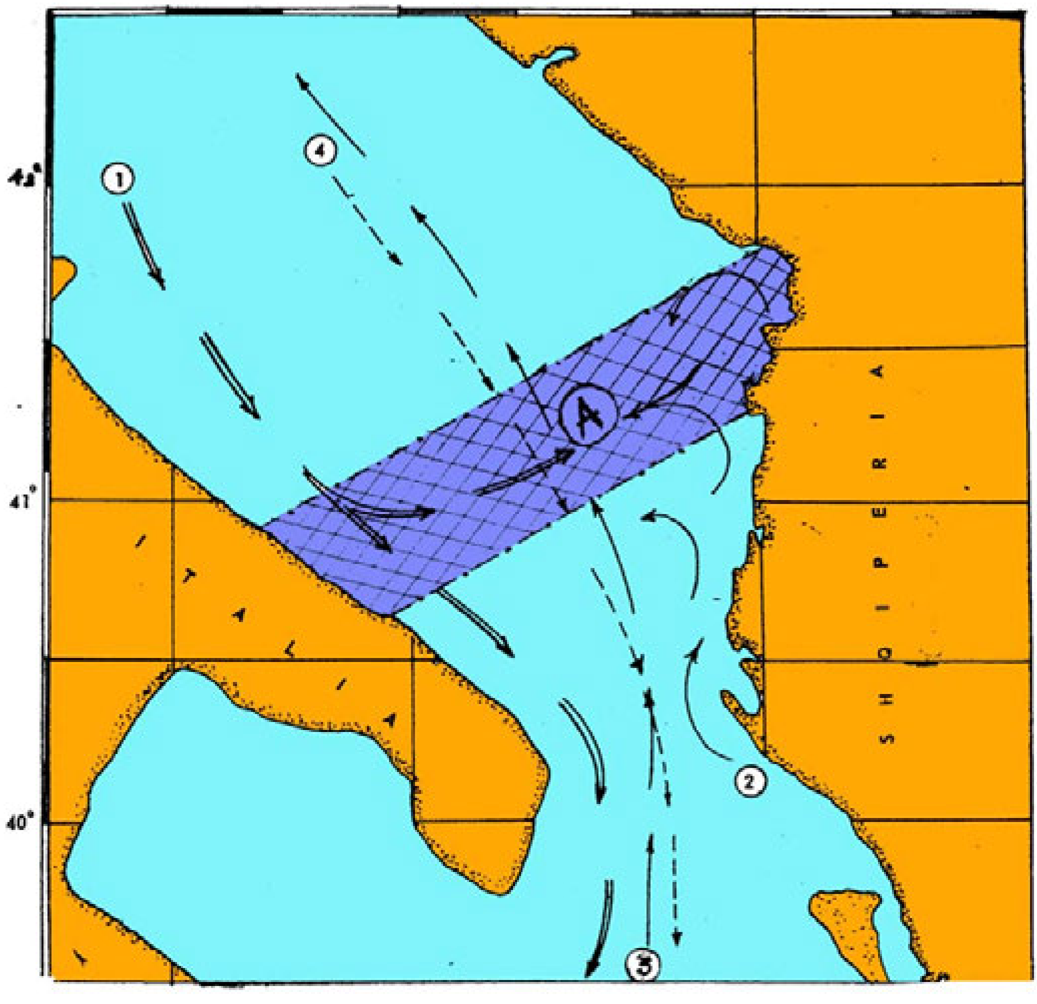

Fig. 14. "The Bridge" of continental water in the Adriatic Sea.
1. Adriatic Deep Water Mass; 2. Eastern Adriaric Superficial Water mass; 3. Intermediate Levantine Water mass; 4. Northern Adriatic Water mass.

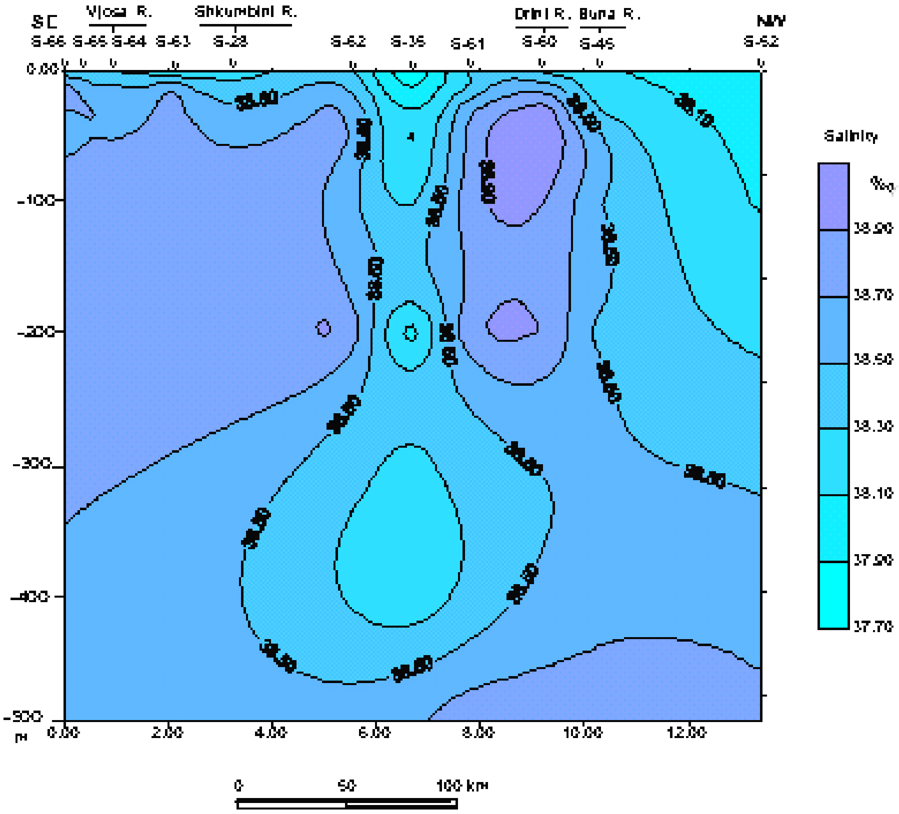

Fig. 15. Vertical salinity section 1-1, Adriatic Sea, wet hydrographical year 1963.

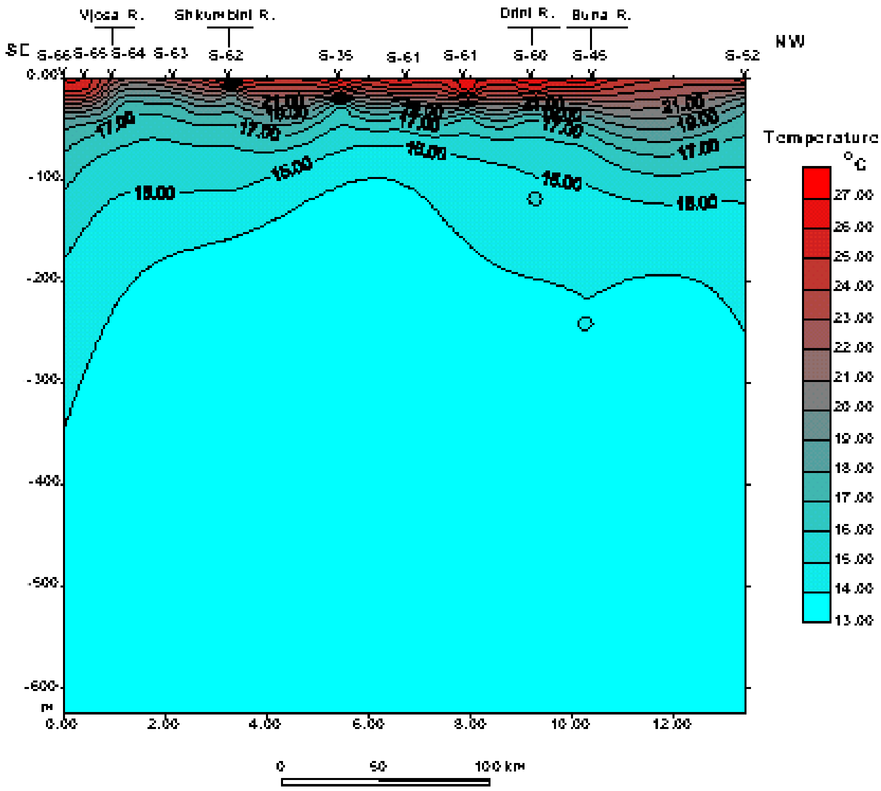

Fig. 16. Vertical temperature section 1-1, Adriatic Sea, wet hydrographical year 1963.

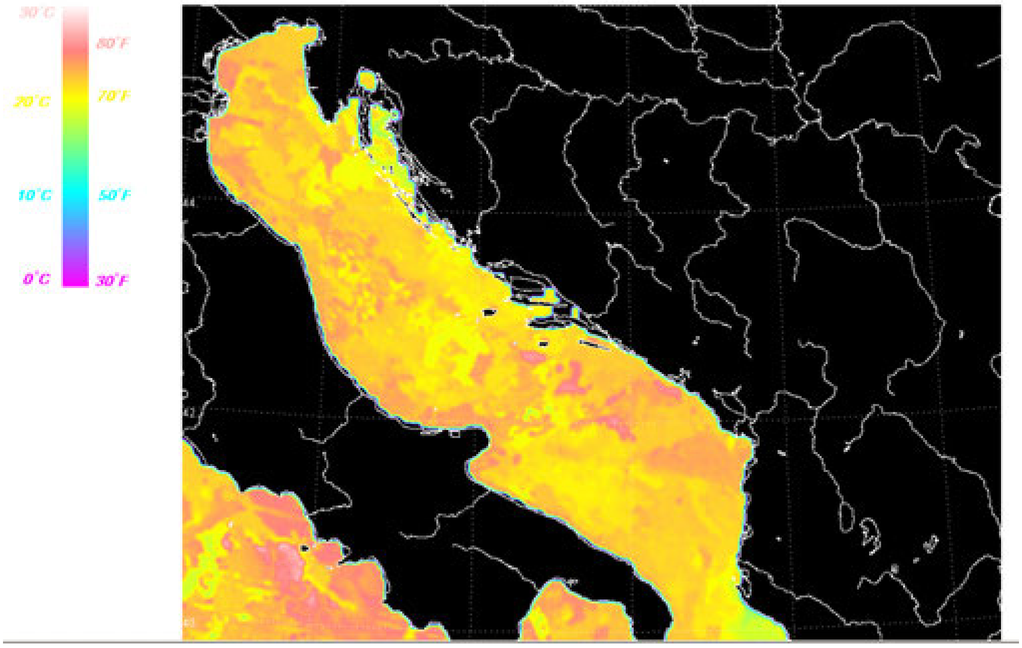

Fig. 17. Adriatic Sea Surface Temperature, restored from NOAA satellite data 19.08.2005 3:50 (GMT) NOAA 12 (Sputnik.SST, 1999 SMIS IKI RAN, Moscow, Russia).

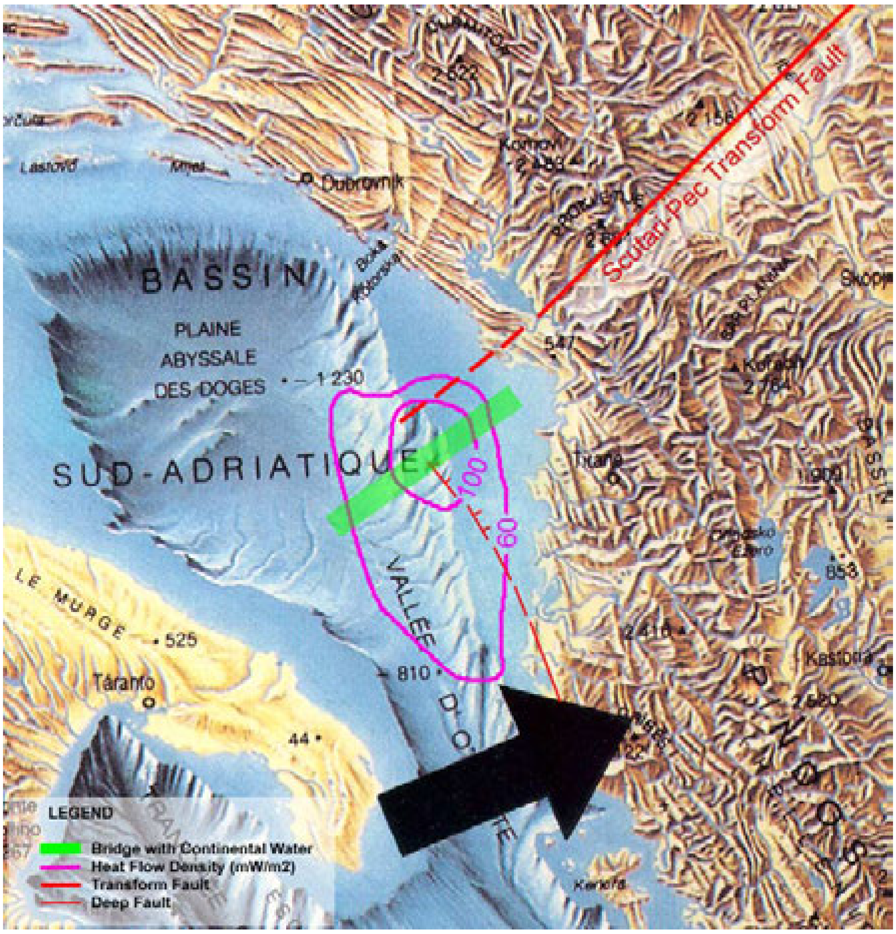

Fig. 18. Adriatic Heat Flow Density Anomaly (Geothermal Atlas of Europe, 1992).

6. Conclusions

- Albanian littoral has two major units: accumulative Adriatic coastline and erosive Ionian seaside.
- Albanian Adriatic coastline has an intensive change and continuously modifying its shape.
- Submerged process, caused by neotectonic activity, is observed in some sectors within accumulative Adriatic coastline.
- The climate at coastal plane region of Western of Albania has a warming of 0.6 K occurred, from last quarter of 19^{th} until present-day. These climate changes have their impact on country water system, on and water resources, on the erosion processes, and on the hydrographic regime of the Adriatic Sea.
- The oceanographically situation in the Adriatic Sea is characterized by the formation of "The bridge" with continental water in the Adriatic Sea. "The bridge" is closely linked with the intensity of the Albanian rivers flow to the sea.

7. Acknowledgments

Authors gratefully acknowledge to the Institute of Hydrometeorology and Institute of Informatics and Applied Mathematics of Academy of Sciences of Albania, Geophysical Section in the Faculty of Geology and Mining, Polytechnic University of Tirana, Geophysical Institute of Academy of Sciences in Prague, for the possibilities which have create during the years for realization of the hydrologic and hydrographic studies and climate change investigation. Authors grateful acknowledge to the Prof. Umberto Simeoni, Farrara University, Italy, Shuitsky Yu. D., Odessa State University, Çermak, V and Safanda, J., Geophysical Institute of Academy of Sciences in Prague, for long period of the scientific collaboration and joint studies.

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10. Pictures Album

Photo 1. Albanian Adriatic Sea Littoral, Semani-Karavasta accumulative area.

Photo 2. View of erosive Adriatic Coastline, Vlora Bay.

a)

b)

Photo 3. Velipoja accumulative sandy beach (a) and Buna River Mouth Split (b).

a)
Photo 4. Accumulative sandy Adriatic Coastline, Durrësi Beach.

b)
Photo 4. Accumulative sandy Adriatic Coastline, Golemi Beach, Durrësi Bay.

Photo 5. Present day's macro fauna in the solonchak Quaternary littoral deposits, Rrushkulli area.

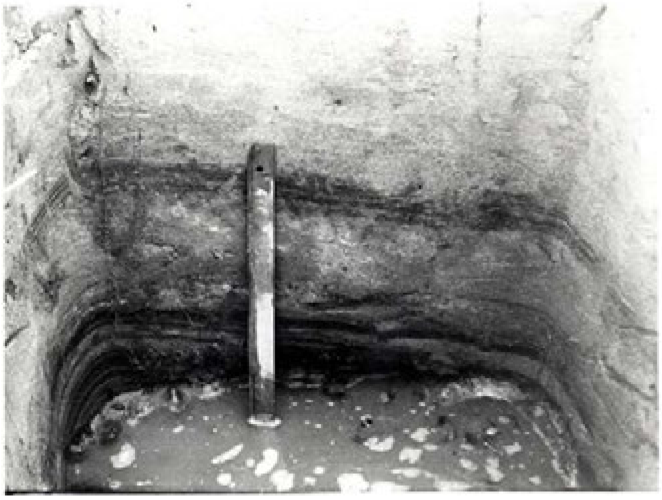

Photo 6. Heavy and rare minerals placer in sand dunes, Rrushkulli area.

a)

b)
Photo 7. Buried sand knolls, Rrushkulli (a) and Semani (b) areas.

Photo 8. Erosive Currila Coastline area, northern of Durrësi city.

a)

b)

Photo 9. View of submerged Semani beach area.
a) Semani submerged coastline panorama;
b) Semani deep well drilled onshore, actually the basement in Adriatic Sea waters

Photo 10. View of submerged Patoku Beach area.

Photo 11. View of the new sand split at the Patoku area.

Photo 12. View of Narta Lagoon in the erosive Adriatic Costline, Vlora area.

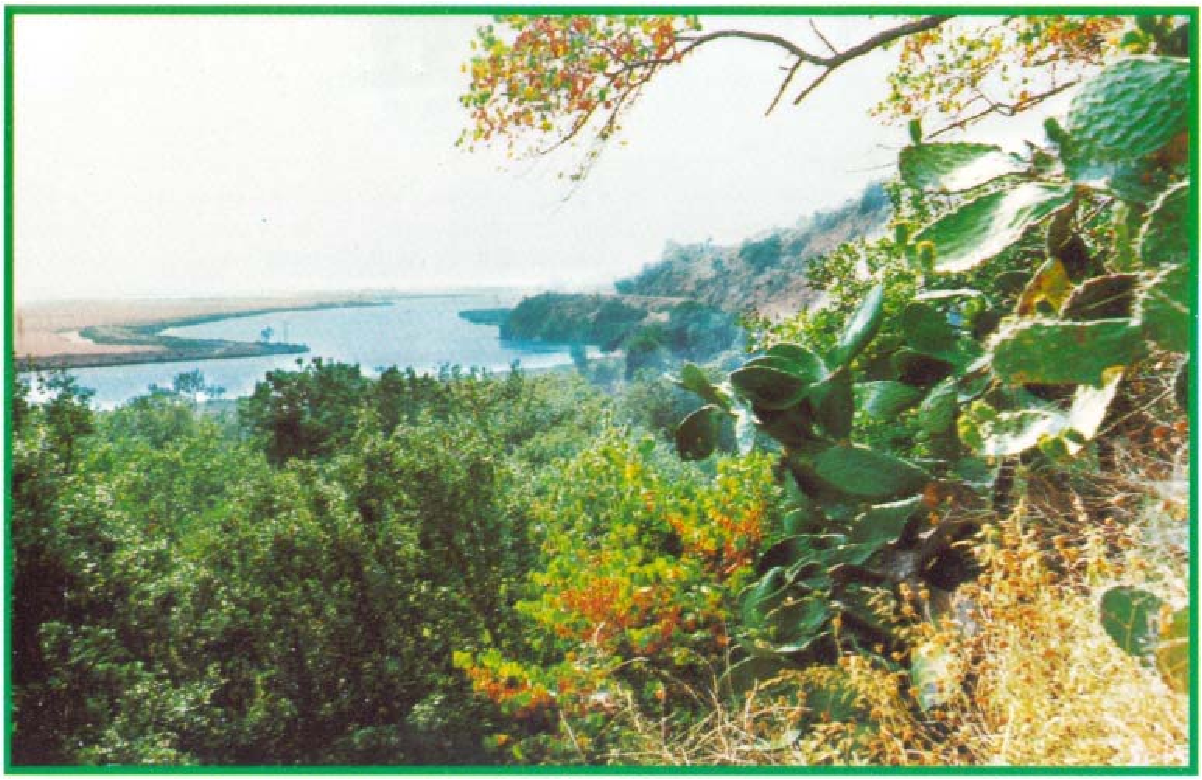

Photo 13. View of erosive Ionian Coastline, Butrinti Lagoon area.

Photo 14. Erosion Ionian Sea Coastline, Ksamil area at the Albanian Riviera.

Photo 15. Solid discharge of the Mati River to the Adriatic Sea.

ALFRED FRASHËRI

KONTROLLI DHE MONITORIMI I QËNDRUESHMËRISË SË SHPATEVE DHE RRËSHQITJEVE

Tiranë, 2011

ALFRED FRASHËRI

KONTROLLI DHE MONITORIMI I QËNDRUESHMËRISË SË SHPATEVE DHE RRËSHQITJEVE

Tiranë, 2011

Internet site: http://itc.upt.al/~nfra/lslide/

TREGUESI I LËNDËS

PARATHËNIE

Studimi Kontrolli dhe monitorimi i qëndrueshmërisë së shpateve dhe rrëshqitjeve që po paraqitet në këtë leksion është përgatitur mbi bazën e kreut të tretë të librit “Gjeofizika inxhinierike dhe mjedisore”, botim i Akademisë së Shkencave dhe i Fakultetit të Gjeologjisë dhe Minierave, Tiranë 2005, (ISBN 99943-763-5-7), i autorit Alfred Frashëri.

Ky leksion ka pasqyruar edhe arritjet e reja të studimit dhe monitorimit të shpateve dhe rrëshqitjeve gjatë këtyre pesë vjetët e fundit, si edhe problematikën e dukurisë së rrëshqitjeve intensive në të gjithë territorin e Shqipërisë në dimrin e vitit 2010.

Autori do të konsiderojë se ka kryer detyrën e vet nëse ky libër do të japë ndihmesën e vet në drejtim të studimit kompleks të qëndrueshmërisë së shpateve dhe të rrëshqitjeve, si edhe të monitorimit të dinamikës së zhvillimit të rrëshqitjeve me anën e metodave dhe teknologjive moderne bashkëkohore, nga ana e instiucioneve të specalizuara, për të evituar humbjet njerëzore dhe për të minimizuar humbjet e mëdha materiale. Por mbi të gjitha është e nevojshme që ligjvënësit dhe administrata shtetërore qëndrore dhe lokale duhet të përgatisin legjislacionin përkatës dhe të kërkojnë zbatimin e ligjeve me rigorozitet për të evituar impaktin njerëzor në shkaktimin e prishjes së qëndrueshmërisë së shpateve dhe zhvillimin e rrëshqitjeve. Eshtë problem i ngutshëm i ditës që të merren edhe masat e duhura për monitorimin e rrëshqitjeve të njohura, për të minimizuar dëmtimet dhe evituar katastrofat.

Leksioni do tu shërbejë edhe studentëve të fakulteteve inxhinierike, të cilët në profesionin e tyre kanë lidhje me dukurinë e rrëshqitjeve.

Autori

1. QËNDRUESHMËRIA E SHPATEVE DHE DUKURIA GJEOLOGJIKE E RRËSHQITJEVE

Shpatet janë sistem dinamik i gjeomjedisit. Dukuri të ndryshme vrojtohen në sistemet e shpateve, të cilat lidhen me çvendosjen e masave të shpateve:

- Rënie e gurëve
- Rënie e shkëmbinjve
- Rëshqitje e deluvioneve
- Rëshqitje e copërinave
- Rrjedhje e copërinave
- Copëtimi i shkëmbinjve rrënjësorë
- Rëshqitje bllokore
- Rëshqitje
- Fluksi rëror nënujor

Rrëshqitjet janë një dukuri e rrezikut gjeologjik, të cilat marrin jetë njerëzish dhe shkaktojnë dëme të mëdha në të gjithë vendet e botës, kryesisht në rajonet malore dhe bregdetare.

Rrëshqitjet nuk shfaqen papritur. Në to zhvillohet një process i i gjatë i deformimeve të masivit shkëmbor, akumulim i sfrocimeve, ndryshime mineralogjike dhe çlirimi i sforcimeve shoqërohet me lëvizjen e trupit të rrëshqitjes, që ndodh vetëm në fazën e fundit. Mundësia për ndonjë lëvizje rrëshqitjeje, si edhe shfaqje të ngjarjeve të tjera si ortekëve të gurëve, rrëshqitjeve të gurëve dhe shëmbjes së tyre, janë lidhur drejtprësëdrejti me kushtet mekanike dhe gjeologjike të shkëmbinjve dhe formacioneve. Faza katastrofike e ndonjë ngjarje gjeologjike gjithmonë paraprihet nga faza e përgatitjes së saj, e cila përfaqëson akumulimin e ndyshimeve të pakthyeshme në brëndësi të mjedisit gjeologjik. Karakteri dhe shkalla e këtyre ndryshimeve përcaktohen nga klasa e ngjarjeve gjeologjike dhe përmasat e tyre. Veçoria kryesore e kësaj faze përgatitore, në rastin e ngjarjeve të rrëshqitjes, është formimi i kushteve për çlirimin e energjisë së akumuluar paraprakisht.

Humbja e qëndrueshmërisë mekanike, paraprihet nga faza e paqëndrueshmërisë lokale, e cila në pajtueshmëri të plotë me parimet sjellëse të sistemeve të komplikuara mekanikë në mjediset me kushte të paqëndrueshëm, karakterizohet nga rritja e ndjejshmërisë së masivit shkëmbor ndaj ndonjë turbullimi të jashtëm.

Mekanika e përgatitjes dhe zhvillimit të ngjarjeve rrëshqitëse lidhen me shfaqjen e zhvendojeve të ndryshme në pjesët e strukturuara të masivit shkëmbor, si edhe me formimin e zgjerimit të sipërfaqes e "zgjimit" të sfrocimeve, pas të cilave shfaqet rrënia e gurëve ose rrëshqitja. Faza aktive e përgatitjes së procesit të ngjarjeve rrëshqitëse karakterizohet nga reduktimi i kohezionit të elementëve strukturalë të masivit shkëmbor, si edhe gjithashtu nga rritja e lëvizshmërisë të këtyre elementëve në masiv, si një tërësi ose përgjatë sipërfaqes së dobësuar që formohet.

Eksperienca e studimit të proceseve të shpateve tregon se në fazën që i paraprin zhvillimeve katastrofike të ngjarjve të shpatit, është e mundur te vrojtohen manifestimet mekanike të mëposhtme:

- ndryshime të relievit (jo vetëm zhytje dhe zhvendosje të dukshme të shkëmbinjve, por gjithashtu edhe tregues të tjerë gjeomorfologjikë),
- deformacione lineare ose këndore anomalisht të larta, nëse do të krahasohet me luhatjet ditore (24 orëshe) dhe sezonale të këtyre deformimeve,

Përgjithësisht, studimet e rrëshqitjeve aktualisht orientohet drejt përcaktimit të karakteristikave fizike-gjeologjike dhe veçoritë e strukturës së tyre. Detyrat kryesore janë:

- përcaktimi i sipërfaqes së rrëshqitjes dhe i zonave të kontakteve, përgjatë të cilave zhvillohet lëvizja e masave shkëmbore,
- përcaktimi i formës, i përmasave dhe gjendjes hapësinore të trupit rrëshqitës,
- përcaktimi i prirjeve kryesore të kontaktit dhe linjave tektonike, përgjatë të cilave zhvillohet lëvizja e masave shkëmbore, në raport të drejtpërdrejtë me aktivitetet hidroteknike dhe të drejnazhit të ujërave spërfaqësore dhe nëntokësore ,
- kontroll i proceseve të deformimeve nëpërmjet matjeve sistematike në pajtim me metodave të zhvilluara në raport me parashikimin e rriskut të proceseve gjeodinamike.

Opinion i përbashkët lidhur me papritshmërisë së ngjarjeve rrëshqitëse katastrofike bazohet në faktin shpejtësitë dhe amplitudat e vogla të proceseve deformuese zakonisht nuk lejojnë regjistrimin e ngjarjeve anomale me anën e metodave tradicionale.

Dinamikën e rrëshqitjeve dhe të ndryshimeve në qëndrueshmërinë e shpateve e përcaktojë proceset gjeologjike dhe fizikë.

2. DUKURIA E RRËSHQITJEVE NË SHQIPËRI

Shqipëria është vend malor dhe gjeologjia e Albanideve përfaqësohet nga struktura, litologjia e të cilave krijon kushte për paqëndrueshmërinë e shpateve dhe zhvillimin e rrëshqitjeve (Fig. 1). Bazuar në formacionet gjeologjike dhe masën e trupit rrëshqitës, mund të bëhet klasifikimi i më poshtëm i rrëshqitjeve në Shqipëri:

***1 .Shpate të paqëndrueshme dhe zhvillimi i rrëshqitjeve intensive në shkëmbinjtë e tjetërsuar dhe në shtresat e mbulesës në brigjet e liqeneve, kryesisht në hidrocentraleve*.**

Rrëshqitje tipike të tilla është zhvilluar në Ragam në bregun e liqenit të Vaut të Dejës (Foto 1, 2, 3, 4), si edhe është riaktiviazuar intensivisht rrëshqitja e mirënjohur e Poravës në bregun e liqenit të hidrocentralit (Foto 5, 6, 7) në lumin Drin.

2. Shpate të paqëndrueshme dhe zhvillimi i rrëshqitjeve intensive në shkëmbinjtë e formacionit flishor paleogjenik.

Formacionet e paqëndrueshme, si ato flishore etj. kanë përhapje të madhe në territorin e vendit ku janë vrojtuar shpate të paqendrueshëm, prandaj shtrirja e këtyre dukurive nuk kufizohet në një lokalitet apo trevë. Paqëndrueshmëria e shpateve është potenciale në shume zona të vendit, prandaj studimi i kësaj dukurie ka rëndësi kombëtare. Shembuj tipikë të zhvillimit të rrëshqitjeve janë ato në fshatrat Guri i Zi në Elbasan (Foto 8), Gjyras në Maliq, në Moglicë të Oparit etj., të cilat kanë arritur përmasa dhe intensitete të tilla sa që

kanë shkaktuar shkatërrimin e ekosistemeve, me të gjitha pasojat e tyre, si edhe dëme ekonomike shumë të mëdha, etj. Rrëshqitje e madhe ka qenë edhe ajo në tunelin e devijimit të Banjës në Gramsh (Foto 9), etj.

3 .Shpate të paqëndrueshme dhe zhvillimi i rrëshqitjeve intensive në shkëmbinjtë molasikë të neogjenit. Tipike është rrëshqitja e zhvilluar në depozitimet molasike të pliocenit-mesinianit në kodrën e Durrësit (Foto 10, 11,12), si edhe ajo në shpatin e kodrës së Fakultetit të Gjeologjisë dhe të Minierave në Tiranë (Foto 13).

4. Shpate të paqëndrueshme dhe zhvillimi i rrëshqitjeve intensive në depozitimet e shkrifta kuaternare.

5. Vidhisje në shkëmbinjtë e tjetërsuar dhe të shkrifët të cilat zhvillohen kryesisht në skarpatat e rrugëve, të traseve të kanaleve, të hekurrudhave, të shesheve të ndërtimit. Vidhisje janë vërejtur edhe në zonat karstike, veçanërisht në sektorët ku janë formuar zgavra të varrosura “pseudokarstike” në mbulesën e shkrifët argjilore mbi shkëmbinj gëlqerorë ose halogjenë karstikë (Foto 14). Tipike janë edhe rrëzimet e gurëve dhe blloqeve shkëmborë nga faet e maleve ku ndodhen kështjellat si ajo e Krujës (Foto 15), Lezhës, Gjirokastrës, etj.

Prandaj për të mbrojtur ekosistemet, për të realizuar ndërtimin e veprave të sigurta dhe për të shmangur rrezikun gjeologjik në veprat ekzistuese nga dukuria e rrëshqitjes, problemi shtrohet për tu zgjidhur në disa plane (Dhame L., 1974, Frashëri A. etj. 1996, 1997, 1998, 1999, Bushati S. etj. 2008):

1. Prognozimi i mundësisë së zhvillimit të dukurisë së rrëshqitjes. Vrojtimet rekonjicionale komplekse gjeologo-gjeofizike, hidrologjike dhe shpim, mjedisore dhe biologjike për sqarimin e gjendjes së masivëve shkëmbore, të trupit të rrëshqitjes dhe të dëmtimeve të ekosistemeve.

2. Përcaktimi i faktorëve me origjinë gjeologjike-gjeofizike pranësipërfaqësore në krijimin, aktivizimin dhe dinamikën e shkatërrimeve të ekosistemeve në shpatet që rrëshqasin.

3. Përcaktimi i faktorëve të mundshëm antropogjenë në aktivizimin dhe dinamikën e shkatërrimeve të ekosistemeve ose përkeqësimin e tyre.

4. Evidentimi i rrëshqitjeve qysh në fazën fillestare të aktivizimit të rrëshqitjes, kur ende nuk ka shfaqje të dukshme në sipërfaqen e tokës.

5. Studimi i trupit të rrëshqitjes, si edhe monitorimi i vazhdueshëm i dinamikës së zhvillimit të rrëshqitjes.

6. Përcaktimi i masave dhe i rrugëve për ndërprerjen e mundëshme të shkatërrimeve të mëtejshme, si edhe për rikuperimin e ekosistemeve të shkatërruar.

3. RRËSHQITJET DHE IMPAKTI I VEPRIMTARISË SË PAKONTROLLUAR NJERËZORE NË PAQËNDRUESHMËRINË E SHPATEVE NË SHQIPËRI

Dimri i vitit 2010, së bashku me rreshjet e shpeshta dhe të vazhdueshme, po shoqërohet edhe me dukurinë e prishjes së qëndrueshmërisë së shpateve, zhvillimin e rrëshqitjeve dhe shëmbjeve në shumë krahina dhe zona të Shqipërisë. Këto zhvillime janë shoqëruar me një shkallë të lartë rreziqesh dhe dëmtimesh të shtëpive, terreneve dhe objekteve të ndryshme, duke rrezikuar në masë të madhe edhe jetën e njerëzve dhe duke e vështirësuar tej mase atë. Dhjetra familje mbetën në qiellin e hapur këtë dimër. Rikuperimi i mundshëm i këtyre dëmtimeve lidhen me shpenzime ekonomike të mëdha për komunitetin dhe shtetin.

Prishja e qëndrueshmërisë së shpateve, rrëshqitjet dhe shëmbjet janë dukuri natyrore që kushtëzohen nga ndërtimi gjeologjik i territorit, dinamika e ujërave nëntokësore dhe sipërfqësore, bimësia dhe struktura e saj, nga kushtet klimarike dhe verimtaria e agjentëve atmosferike, si edhe tërmetet. Zhvillimi i këtyre dukurive mund të nxitet dhe të përshpejtohet edhe nga verimtaria njerëzore e pakontrolluar në fusha të ndryshme: shpyllëzimet, prishja e strukturës së bimësisë në sipërfaqen e tokës, prishja e strukturës së rrjedhjes së ujërave sipërfaqësore ose nëntokësore, mos ndërtimi i sistemit të drenimit të ujërave në zonat e sheshet ndërtimit, prishja e ekuilibrit të shpateve me ndërtime të papërshtatshme në pajtim me strukturën e shtresave të truallit dhe vetitë fiziko-mekanike të tyre, me gërmimin e skarpatave me pjerrësi të gabuar. Shumë ndërtime, veçanërisht dy dekadat e fundit janë kryer pa studimet e duhura gjeoteknike, si edhe duke ndërtuar kohë pas kohe në nivele të ndryshme hipsometrike të shpateve, pa marrë parasysh nivelin e riskut të rrëshqitjeve në sheshin e ndërtimit.

Në mënyrë të veçantë rrëshqitjet aktivizohen pas ndërtimit dhe gjatë shfrytëzimit të veprave hidroteknike. Këto veprat, përgjithësisht, janë ndërtuar në kushtet e relievit të thyer malor dhe në formacione gjeologjike në të cilat zhvillohet dukuria e rrëshqitjes në Shqipëri. Kjo dukuri është e zhvilluar si në mbulesën e shkrifët ashtu edhe shkëmbinjtë rrënjësore. Shembull i kësaj është rrëshqitja në Ragam në bregun e liqenit të hidrocentralit të Vaut të Dejës (Foto 1, 2, 3, 4. Rrëshqitje tjetër tipike, e madhe e riaktivizuar, është ajo në fshatin Poravë në Fierzë, rreth 2.5 km në lindje të digës së hidrocentralit (Foto 5, 6, 7). Gjatë periudhës mbi 20 vjeçare të shfrytëzimit të hidrocentralit, ndryshimi i nivelit të ujit në liqen dhe filtrimi i ujit në shkëmbinjtë e shpateve të liqenit, ka ndikuar ndjeshëm në ndryshimin e vetive fiziko-mekanike të shkëmbinjve dhe në zhvillimin e dukurisë së rrëshqitjes dhe në aktivizimin e saj të dukshëm.

Parë në këtë kënd vështrim, Shqipëria si vend përgjithësisht malor-kodrinor dhe me formacione gjeologjike, midis të cilave ka edhe nga ato të paqëndrueshme, si edhe i veprimtarisë së pakontrolluar njerëzore, po përballet më pasoja të rënda nga dukuritë që lidhen me rrëshqitjet dhe shëmbjet e masave shkëmbore ose e dherave.

Dy dekadat e tranzicionit kanë sjellë ndërtime të shumta pa asnjë planifikim e kontroll teknik e shkencor, si edhe shkatërrime dhe mosmirëmbajtje të sistemeve kulluese. Kjo veprimtari e pakontrolluar njerëzore është me pasoja të rënda , që po i ndjejmë nga viti në vit gjithënjë e më shumë. Në fotografinë satelitore duket një "lagje moderne" e Tiranës, që tashmë nuk është në periferi të saj, paçka që siç thuhet janë jashtë vijës së verdhë (Foto 16). Të zbritur nga zonat e thella e të varfëra, drejt qytetit ku prisnin të gjenin jetë më të mirë, sejcili ndërtoi ku mundi dhe si mundi. Dhe këta qindra mijë njërëz që shtegtuan drejt Tiranës, nuk gjetën asnjë përkrahje nga shteti dhe institucionet e tij se si duhet të ndërtonin lajen e tyre të re, që është lagje e shekullit të 21-të. Dhe nuk ka nevojë të jesh specilist që të Specialist që të marrësh vesh se këto "paketime" të dëndura shtëpish janë pa kanalizime të ujërave të zeza dhe të bardha, dhe pa infrastrukturën me sistemin e rrugëve dhe mjediseve publike për një lagje të shekullit ku jetojmë. Ujërat që derdhen të pakontrolluara në nëntokë shkatërrojnë strukturën e truallit, duke sjellë dëmtime të godinave. Janë ndëruar edhe shtëpi në shpate të pa qëndrueshëm, që nën peshën e ndërtimit dhe dukë mos patur kanalizimet e duhura, shpatet bëhen të pa qëndrusheme dne rrëshqasin, duke sjellë çarjen e shtëpive, aq më tepër kur bien shira të dëndur. Madje, papërgjegjshmëria ka arritur në nivele të tilla sa sa janë lejuar të ndërtohen shtëpi nën trupa të rrëshqitjeve ose në shpate të paqëndrueshme, siç ndodh edhe në Durrës, në kodrën ku ndodhet vila e mbretit (shih foto 17, 18, 19).

Fshatra të tërë ose lagje të tyre rrëshqasin, si rasti i njohur i Moglicës, si edhe i shumë lagjeve në fshatra të ndryshme të vendit gjatë këtij dimri. Edhe nën diga janë lejuar të ndërtohen shtëpi, dukë patur mbi kokë ujërat e liqeneve, që mund ti përmbytin në rast se çahet diga prej dheu, si në Ragam të Vaut të Dejës ose në Paskuqan të Tiranës etj. (shih foto satelitet 1, 2).
Vërehen shëmbje edhe në monumete të kulturës, si për rreth keshtjellave, ose objekteve të ndryshme monumentale, veçanërisht pas gërmimeve pranë tyre (Foto 15).

Në brigjet e liqeneve të hidrocentraleve janë zhvilluar rrëshqitje me rrezishmëri të lartë, si në Poravë pranë Fierzës ose në Ragam, pranë Vaut të Dejës, për arsye se masat e shkëmbinjve që rrëshqasin bien drejtpërdrejt në liqenet e hidrocentraleve dhe, duhet patur parasysh që masa e trupit të rrëshqitjen në Poravë është rreth 40 milion metër kub. Shumica e shtëpive në Poravë janë të çara, siç duket në fotografi. Edhe në Ragam rrëshqet një faqe kodre. Dhe për fat të keq edhe këto rrëshqitje nuk monitorohen.

Shpyllëzimet e bëra kanë zhveshur mijëra hektarë dhe zona të tëra të, si edhe është prishur struktura sipërfaqsore e veshjes bimore, duke rritur shkallën e erozinit dhe shkatërruar rrugët e drenimit të ujërave sipërfaqësore, çka duket qartë në fotografitë satelitore (Foto 20). Kjo veprimtari ka krijuar edhe kushte për prishjen e qëndrueshmërisë së shpateve dhe formimin e rrëshqitjeve.

Janë të shumta rrëshqitjen ose shëmbjet në rrugët automoblistike, midis tyre edhe ato të ndërtuara vitet e fundit, çka dëshmon ose që janë trasuar në zonë të pa përshtatshmë, ose janë ndërtuar me skarpata të gabuara, në papajtueshmëri me fortësinë e shkëmbinjve të shpateve (Foto 21, 22).

Në këto kushte, është koha për të dhënë kontributin shkencor lidhur me shmangien ose minimizimin e rreziqeve nga këto dukuri natyrore, për analizën rast pas rasti të kësaj dukurie të dëmshme, si edhe sa më parë duhet të fillojë monitorimi i rrëshqitjeve më rrezikshmëri të lartë. Vlerësimi i qëndrueshmërisë së shpateve, i rreshqitjeve dhe monitorimi i dinamikës së tyre duhet bërë me metodat multidisciplinore bashkëkohore gjeologjike-gjeofizike dhe jo me një vështrim sipërfaqësor si turist. Natyrisht, për këtë duhen të angazhohen specialistët dhe shkencëtarët më të mirë të fushës nga institucionet shkencore të ndryshme të vendit.

Por kjo nuk mjafton. Shkaqet e paqëndrueshmërisë së shpateve dhe të krijimit të rrëshqitjeve, të shëmbjeve dhe rreziqet nga zhvillimi i tyre duhen analizuar ngushtë edhe me impaktin e veprimtarisë njerëzore të pakontrolluar për prishjen e qëndrueshmërisë së shpateve dhe gjenerimin e rrëshqitjeve dhe shëmbjeve. Kjo në rradhë të parë është punë e ligjvënësve dhe e organeve shtetërore kompetente. Ka ardhur koha që të punojnë për të mos lejuar të shkatërrohet më tej vendi, çka me mosveprim është shkaktuar këto njëzet vjet të tranzicionit. Sa më parë duhet të bëhen përmirësimet e legjislacionit për ruajtjen dhe mbrojtjen e mjedisit, monitorimin e rrëshqitjeve, si edhe për projektimet dhe ndërtimet e veprave të ndryshme edhe në lidhje me dukurinë e rrëshqitjeve.

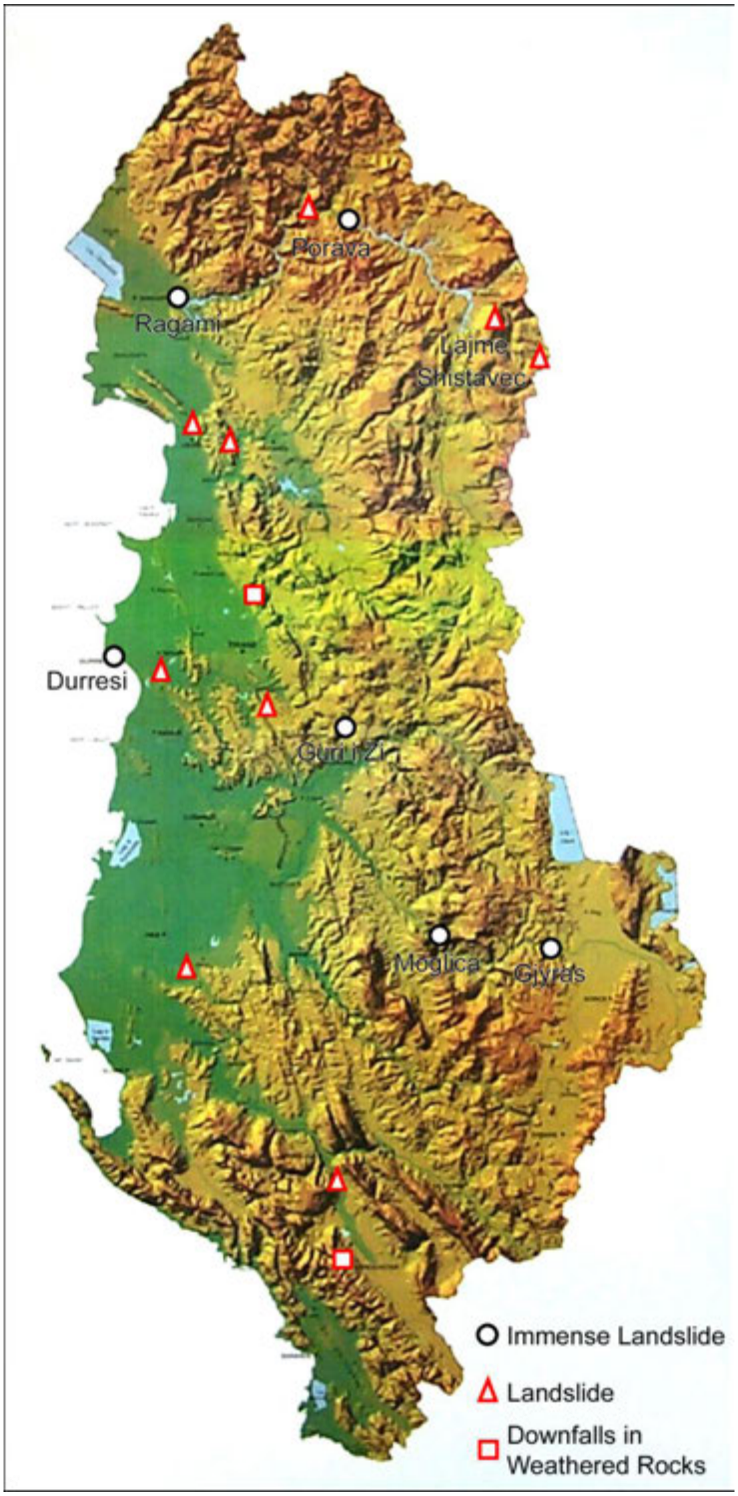

Fig. 1. Rëshqitjet më të mëdha në Shqipëri.

Foto 1. Pamje satelitore e digës së Ragamit, Vau i Dejës dhe rrëshqitjes pranë saj

Foto 2. Pamje satelitore e digës së Ragamit, Vau i Dejës dhe rrëshqitjes në veri të saj

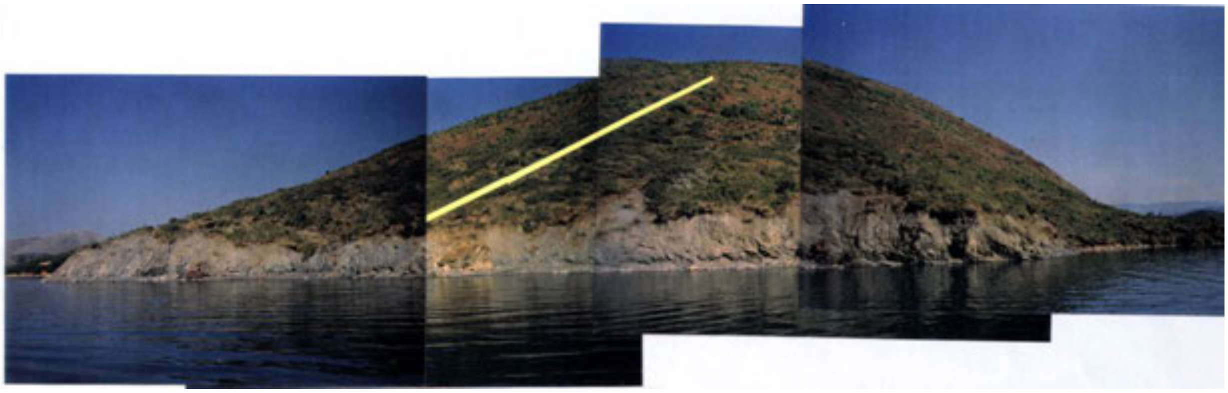

Foto 3. Pamje e përgjithëshme e rrëshqitjes së Ragamit në Vaun e Dejës, ku tregohet edhe pozicioni i njërit nga profilët gjeofizikë (Korrik 1996).

Foto 4. Shkëmbinjtë serpentinitë të milonitizuar në ballin e rrëshqitjes së Ragamit në bregun e liqenit të Vaut të Dejës (Korrik 1996).

Foto 5. Pamje satelitore e digës së Hidrocentralit të Fierzës dhe rrëshqitja në fshatin Poravë në lindje të saj

Foto 6. Pamje e përgjithëshme e rrëshqitjes së Poravës, me vendkalimin e profilit gjeofizik.

Foto.7. Pamje e godinave të çara në fshatin Poravë nga veprimi i rrëshqitjes (Dhjetor 1996).

Foto 8. Pamje nga rrëshqitja në fshatin Guri i Zi, Labinot,Elbasan.

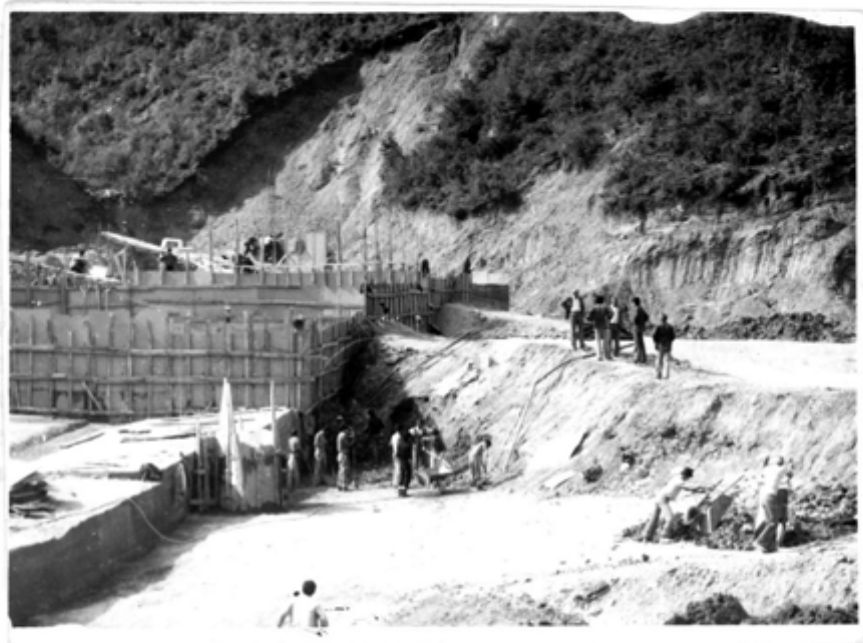

Foto 9. Pamje nga rrëshqitja në veprën hidroteknike të Banjës (Korrik 1987).

Foto 10. Pamje satelitore e kodrës së Vilës së Mbretit Zog në Durrës dhe shpatet me rrëshqitje.

Foto 11. Pamje nga rrëshqitja në kodrën e Durrësit

Foto 12 Pamje e çarjes së godinës së Vilës së Mbretit Zog nga rrëshqitja në kodrën e Durrësit.

Foto 13. Pamje e rëshqitjes në shpatin e kodrës së Parkut të Tiranës.

Foto 14. Pamje nga vidhisje dheu mbi një gropë pseudokarstike;

Foto 15. Rrëzime gurrësh në shpatin e kodrës së kështjellës së Krujës

Foto 16. Pamje satelitore e ndërtimeve të reja pa asnjë planimetri urbane në Tiranë

Foto 17-a. Shlyllëzimet masive janë njëra nga arsyet keryesore të rritjes së intensitetit të errozionit dhe zhvillimit të rrëshqitjeve

Foto 17-C. Shpyllëzimet masive në Tuç

Foto 17-c. Shpyllëzimet masive në Qafë-Mali, Lajthizë

Foto 18. Zhveshja e sipërfaqes së Tokës nga terracat pa sistemet e drenazhimit të ujërave sipërfaqësorë

Foto 18. Skarpata më të pjerrëta sesa lejon fortësia e shkëmbinjve serpentinitë në rrugën Elbasan-Librazhd, ku ka rrënie gurrësh në trasenë e rrugës gjatë shirave

Foto 19. Pamje satelitore e rrëshqitjes në skarpatën e rrugës së re Tepelenë-Gjirokastër.

Foto 20. Pamje satelitore e digës së rezervuarit të Paskuqanit në Tiranë, nën të cilën janë ndërtuar shumë banesa.

4. METODIKA KOMPLEKSE PËR STUDIMIN DHE MONITORIMIN E QËNDRUESHMËRISË SË SHPATEVE DHE RRËSHQITJEVE

Studimet e integruara komplekse gjeologo-gjeofizike inxhinjerike, hidrogjeologjike, dhe gjeodezike, lejojnë të studiohen shpatet dhe të përcaktohen shkaqet e zhvillimit të dukurisë së rrëshqitjve, të prognozohet dinamika e aktivizimit të tyre, të përvijohen masat që duhen marrë për të shmangur viktimat njerëzore dhe për të minimizuar dëmtimet e ekosistemeve dhe të humbjeve ekonomike. Rezultatet e këtyre studimeve janë të domosdoshme edhe për të projektuar masat e nevojshme tekniko-ekonomike për të rikuperuar ekosistemet e shkatërruar. Ky studim integral i kontrollit të riskut të rrëshqitjeve është një procedurë e përafrimit të një pas njëshëm, që bazohet në njohjen e ligjësive të strukturës së Tokës, kontroll i thellë i ndërtimit të brëndshëm të zonave të rrezikuara, si edhe vrojtimet e lëvizjeve të vogla në brëndësi të trupave kritikë, që konsiderohen potencialisht të gatshëm për të rrëshqitur poshtë. Metodika multi disiplinore ka si synim të krijojë një kontroll të përgjithshëm dhe të integruar, i cili ka mundësi të përcaktojë sheshet e rrezikshme, të bëhet klasifikimi i tyre në varësi të nivelit të riskut të rrëshqitjes, si edhe të krijohet një metodë për vrojtmin e vazhdueshëm të riskut të rrëshqitjes. Kontrolli, nga një anë duhet të jetë mjaft universal, që të përshtatet në mos në të gjitha rrëshqijet por në shumicën e rasteve, si edhe nga ana tjetër të jetë mjaft fleksibël, për tu përshtatur me çfarëdo kushtesh gjeologjike dhe sipërfaqësore lokale. Por, megjithëse janë zhvilluar shumë metoda për dallimin e përgjithshëm të shpateve të rrezikuara dhe që kanë nivel të ndryshëm rrezikshmërie, deri më sot, komuniteti tekniko-shkencor dhe i biznesit ende nuk kanë përshtatur dhe zbatuar një metodologji universale të pranueshme, që të jape ndihmesë për parashikimin dhe menaxhimin tërësor të rrëshqitjeve në të gjitha rastet. Ende nuk ka një përcaktim thelbësor se cili kompleks metodash kontrolluese dhe monitoruese është më e përshtatshme për secilën fazë të nivelit të rrezikshmërisë. ***Prandaj aktualisht është shumë e domosdoshme zhvillimi i një sistemi monitorues për parashikimin e hershëm të rrëshqitjeve dhe i një sistemi rreziku që të japë tregues për lëvizjet e shpatit në të ardhmen, për periudhën kur ka ende kohë të mjaftueshme për të marrë masat e duhura.***

Bashkësia e metodave mund të përdoret për:

- gjetjen e shpateve potencialisht të rrezikshme: interpretim i përbashkët i imazheve hapësinorë me rezolucion të mesme dhe të lartë, i fotografive ajrore, si edhe i të dhënave gjeologjike-gjeofizike-gjeodezike ekzistuese për dallimin e zonave potencialisht të rrezikshme dhe struktures së linjave tektonike dhe blloqeve të shkëmborë në territoret në studim,
- klasifikimin e zonave sipas nivelit të rrezikshmërisë bazuar në rezultatet e interpretimit të vrojtimeve në distancë dhe të dhënave ekzistuese gjeologo-gjeofizike-gjeodizike ekzistuese dhe koncetrimin e mëpastajshëm të studimeve dhe kontrolleve në zonat më të rrezikuara,
- studimin dhe kontrollin e detajuar të shpateve të rrezikuar. Kontroll inovativ i saktësisë së lartë i strukturës së brëndshme në thellësi kryhet me ndihmën e metodës së mikro-sondimeve sizmike, krahas me tomografitë sizmike dhe gjeoelektrike,
- gjetjen e zonës ku mund të ndodhin lëvizje rrëshqitëse (rrafshe rrëshqitëse) brënda shpateve të rrezikuar, duke interpetuar në kompleks rezultatet e tomografie gjeofizike dhe të mikro-sondimeve sizmike, së bashku me të dhënat ekzistuese gjeologjike-gjeofizike.gjeodizike,
- diktimin e lëvizjeve të brëndëshme në shpatet, me anën e vrojtimeve përsëritëse të zhvendosjeve të brëndshme të shkëmbinjve,

- Instalimi i sistemeve për monitorimin/vrojtimet përsëritëse brënda shpateve më të rrezikuar.
- vlerësimi i riskut gjeologjik,
- krijimin e bazës së të dhënave për rrëshqitjet.

Duke u bazuar në të gjithë këtë informacion kompleks të integruar krijohet mundësia për:

- **Realizmin e planifikimit urban të bazuar edhe në vlerësimin e këtye dukurive,**
- **Projektimin e sigurtë të veprave të ndryshme ndërtimore,**
- **Projektimin e masave inxhinierike dhe për të bërë vlerësimet ekonomike për rehabilitimin e rrëshqitjeve.**

Metodat për studimin e rrëshqitjeve janë zhvilluar gjatë disa dekadave. Ato kanë synuar në regjistrimin e lëvizjeve rrëshqitëse të mundëshme, duke preferuar mundsisht qysh nga fazat e herëshme.

Studimet gjeologo-gjeofizike inxhinjerike dhe vrojtimet gjeodezike të kryera për studimin e qendrueshmërisë së shpateve dhe të rëshqitjeve, si edhe për monitorimin e tyre në Shqipëri kanë qënë programuar për zbatimin në tre drejtime:

1. Vrojtime komplekse gjeologo-gjeofizike sipërfaqësore dhe vendosja e reperëve gjeofizike dhe gjeodezike.
2. Shpimi i puseve të cekët, vrojtime sizmike pus-sipërfaqe dhe karotazhe.
3. Vrojtime gjeofizike dhe gjeodezike në puset dhe në sipërfaqen e tokës.

Me këto punime komplekse është përcaktuar forma dhe struktura e trupave rrëshqitës, janë vlerësuar vetitë fiziko-mekanike të trupit rrëshqitës dhe shkëmbinjve rrënjësorë, është regjistruar niveli i veprimtarisë sizmo-akustike natyrore e rrëshqitjes. Këto të dhëna japin ndihmesë për të vlerësuar qëndrueshmërinë e shpatit dhe dhe dinamika e rrëshqitjeve.

Studimi dhe metodat të përdorura aktualisht i përkasin disa fazave:

1. Punime përgatitore: a) Përzgjedhja e zonave të gjera të ekspozuara ndaj rrezikut të rrëshqitjeve.
b) Përgatitja e kompletit të imazheve hapësinore me rezolucion të lartë dhe të mesëm, i të dhënave ekzistuese gjeologjike-gjeofizike- gjeodezike për zonat e përzgjedhura.

2. Krijimi i modelit gjeologjik krahinor: a) interpretim i përbashkët i imazheve hapësinore, si edhe të dhënat gjeologjike dhe gjeofizike,
b) Krijimi i modelit paraprak gjeologjik i territorit.

Ky model bazohet në:

- Analizën kompiuterike të imazheve hapësinorë duke përdorur metodat standard, përfshirë edhe paketën e softuerit LESSA (Lineament Extraction and Stripe Statistical Analysis, Analizë Statistikore e Nxjerrjes dhe Fshirjes së Tipareve).

- Skemat e prishjeve tektonike dhe blloqeve të strukturës për territoret në studim.

- "Monitorimin retrospektiv", ku imazhet hapësinore që interpretohen krahasohen me imazhe të njejta për territorin e dhënë, por të marra në vitet pasardhës. Kjo bën të mundur

të shikohen procet e reja gjeologjike në zhvillimin e tyre. E njëjta procedurë mund të kryhet edhe për fotografitë ajrore ekzistuese.

- Analizën paraprake e të dhënave disponuese gjeologjike dhe gjeofizike, për të gjetur se si mund të shfaqet në sipërfaqe struktura e thellë me rrëshqitjet "që flejnë". Kujdes i veçantë tregohet për gjetjen e korrespondencës midis rrafsheve të rënies së shtresave të sedimenteve dhe drejtimit të shpateve.

- Raportet përshkrues paraprakë (sistemet e treguesve konvencionalë) për hartat dhe skemat e më pasme ndërmjetëse dhe përfundimtare.

- "Portretet fotografikë të peisazhit" të zonave të pritshme duke u bazuar në veçoritë e shfaqura të rrëshqitjes, të cilat mund të reflektohen në imzhet hapësinore, si edhe ndihma e tyre lidhur me strukturat gjeologjike, të njohura sipas të dhënave gjeologjike dhe gjeofizike. Në kriterin e formuluar kriteri për verifikimin e modelit.

j) Hartave kompiuterike dhe paraqitjen 3D të fushave të treguesve bazuar në të gjitha interpretimevet integrale të paraqitura më lart.

3. Klasifikimi i zonave potencialisht të rrëshqitëshme sipas nivelit të rrezishmërisë

Klasifikimi i zonave potencialisht të rrëshqitëshme sipas nivelit të rrezishmërisë, i cili mund të realizohet duke u bazuar në:

- Analizën e thellë të "foto-portreteve të peisazhit" për zonat e pritshme rrëshqitëse,
- Analizën e thellë të hartave kompiuterike dhe paraqitjeve 3D të fushave të treguesve,
- Kriterin e përpunuar për klasifikimin e shpateve,

4. Struktura e brëndëshme e rrëshqitjeve potencialisht të rrezikshme:

- a) Ekzaminimin i detajuar i strukturës së brëndshme të rrëshqitjes potencialisht të rrezikshme, zbulimi i thyerjeve tektonike dhe i rrafshjeve të rrëshqitjes,
- b) Vrojtimi i drejtpërsëdrejti i zhvendisjeve të vogla (prirja e zhvendosjeve) brënda trupave të rrëshqtjeve të mundëshme.

Në këtë mënyrë, zonat potencialisht të rrezikshme mund të zbulohen në bazën e interpretimit të përbashkët të imazheve satelitore të rezolucioneve të larta deri të mesme, si edhe të të dhënave ekzistuese gjeologjike dhe gjeofizike. Duke u bazuar në rezultatet e këtij interpretimi krijohet edhe modeli gjeologjik paraprak i territorit. Prandaj, edhe faza e parë e studimit modern integral bashkëkohor fillon me grumbullimin e imazheve hapësinore satelitore dhe të fotografive ajrore.

Imazhet hapësinore satelitore

Në këto pesë vjetët e fundit, imazhet hapësinore të përftuara kryesisht me anën e Radarëve me Hapje Sintetik (SAR) dhe imazhet me shkallë shumë të vogël spektrozonale, janë përdorur për programet e vrojtimeve satelitore të rrëshqitjeve, sipas programeve të Agjencisë Hapësinore Europiane (Projektet SLAM, ALPS, IGOS Geohazards, MASMOV). Radari Interferometrik Satelitor (InSAR) është një teknikë në të cilën komponentët fazore të sinjalit të kthyer të radarit të dy ose më shumë skemash të Hapjeve Sintetike Radar (SAR), është është propozuar për të zbuluar lëvizjen e trualli (Fig. 2). Nevoja për saktësi më të lartë dhe varësi kohore të rezultateve ka sjellë që këto pesë vjetët e fundit të përfshihet në studim Interferometria Përhapësit të Qëndueshëm (Persistent Scatterer Inteferometry, PSI).

PSI është një teknikë e vrojtimit në largësi, që përdoret për të kalkuluar lëvizjet e vogla individuale të pikave të truallit dhe strukturës në një zonë të gjerë të mjediseve urbane ose gjysmë urbane (Fig. 2). Teknika përdor të dhënat arshivore të radarit satelitor, duke filluar

nga ato të vitit 1992, për të identifikuar veçoritë e rrjetit të përhapësit të qëndrueshëm, d.m.th. të reflektimeve të radarit nga të godinat, urat, ose të veçime natyrore të zhveshjeve të shkëmbinjve, që me matjet me saktësi milimetrike në mënyrë retrospektive krahasohen me të dhënat e arshivës. PSI ka mundësi të furnizojë në kompleks të dhëna si për madhësitë vjetore të lëvizjes edhe për historinë e lëvizjes shumë vjeçare për pika individuale të shpërndara. Koleksioni i imazheve hapësinore të rezolucionit të lartë dhe të mesëm është i aftë të krijojë effekt steroskopik me rezolucion 2-5 m për zonat e përzgjedhura.

Imazhet me rezolucion të ndryshme mund të japin detaje shumë të ndryshme, prandaj duhet të dallohen ato detaje të cilat janë të nevojshme për zgjidhjen e detyrës. Për të njëjtët tipe të imazheve, informacioni varet nga spektri i valëve të radarit, stina e vrojtimit satelitor (lagështia e truallit/mungesa e lagështisë, minimumi i vegjetacionit ose në të kundërt zhvillimi i disa llojeve bimësh, etj.), lartësia e diellit mbi horizont (ose data dhe koha e vrojtimit), si edhe kombinimi ose bashkësia e tyre.

Imazhet për të njëjtën zonë duhen mbledhur edhe për vite të ndryshme, për të realizuar "analizën retrospektive", për të vrojtuar dinamika e shumë proceseve aktuale gjeologjike. Imazhet e SAR, që shpesh kanë rezolucion hapësinor të ulët (zakonisht nga 7-8 m deri 30 m, 1 m vetëm në rastin s satelitit TerraSat), janë të afta të zbulojnë lëvizje të sipërfaqes në shkallë centimetrike, duke përdorur analizën e pikave shënjë (përhapësit e qëndrueshëm).

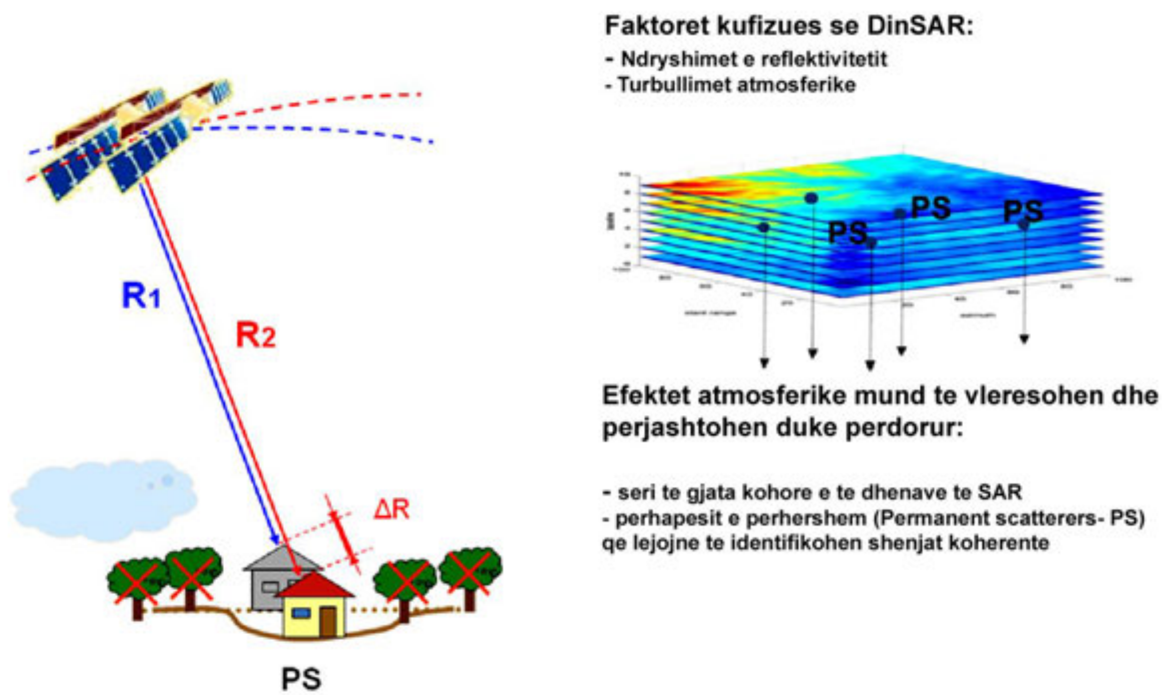

Fig. 2. Teknika e radarit PS (Përhapësit e Qëndrueshëm)
(Geological Survey of Slovenia, 2008-2009)

Është e nevojshme edhe grumbullimi i fotografie ajrore të vjetra de aktuale për të njejtin territor.

Softuerët e PSI analizojnë përgjigjet fazore të pikave shënjë dhe janë të aftë të veçojnë çvendosjet e truallit, lartësinë dhe kontributet atmosferike të fazës për secilën pikë. Siç

rezulton nga këto korregjime arrihet saktësi matje të rendit +/- 0.1 mm/vit të madhësisë së zhvendosjes. Kontributi fazor që i detyrohet atmosfrës vlerësohet për çdo skenë në bazën e të dhënave.

Hartat e lëvizjeve relative të tuallit në zona të gjëra sipas PSI, me saktësi pothuajse milimetrike përgjatë linjës së vizionit satelitor (LOS) në rrafsh vertikal është nën atë që arrihet me GPS. Saktësia absolute hapësinore është rreth 15 m, ndërsa saktësia relative hapësinore është rreth +/- 5 m në drejtimin Lindje-Perëndim dhe 2 m në drejtimin Veri-Jugë. Megjithë këtë, PSI përfaqëson matje me kosto të ulët dhe kohë efektive të shkurtër për kontrollin e lëvizjes së truallit në zona të gjëra.

Zakonisht të dhënat e marra në Bandat X dhe C, d.m.th. me gjatësi valësh 3,1 cm dhe 5,6 cm, që janë përparësia e të dhënave të SAR, nuk mund të përdoren për të bërë “transparencën” e shkëmbinjve të shkrifët, pasi depertueshmëria e valëve me këto gjatësi nuk është më e madhe se disa centimetre, kështu që të dhënat e SAR mund të pasqyrojnë vetëm sipërfaqen e rrëshqitjes por jo të brendësisë së trupit rrëshqitës, qoftë edhe kur rrëshqitja ndodhet në shkëmbinj të shkrifët. Me gjithë se vrojtimet satelitore nuk kanë periodicitet shumë të lartë (nga 2,5 ditë deri 35 ditë për satelitët ekzistues që kanë pajisje SAR), në disa rastë metodat satelitore janë të afta të zbulojnë dukuri katastrofike të lëvizjeve rrëshqitëse që kryhen.

Aktualisht përdoren teknika innovative për analizën e imazheve satelitore të strukturave të thellësisë (Boyarchuk K.A., Maloushina N.I., Miloserdova L.V.). Metoda është bazuar në analizën gjeodinamike të informacionit për sistemet gjeologjike dhe formulimit të imazheve hapësinore duke u bazuar në përmasat e objekteve të interesuara. Rezultatet përfaqësojnë modelin struktural të territorit, i cili mund të detalizohet me anën e të dhënave ekzistuese gjeologjike dhe gjeofizike. Në këto raste, këto të dhëna nuk lidhen mekanikisht me imazhet hapësinore, por ato ndërtojnë dhe pasurojnë modelin, duke sjellë detaje të reja lidhur me ndërlidhjen e brëndëshme të komponenteve. Përparësi e madhe e kësaj metode është aftësia për tu përshtatur për kushte tektonike dhe sipërfaqësore fare të ndryshme, për deri sa kriteret dhe treguesit e rrëshqitjeve variojnë në varësi të kushteve gjeologjike dhe praktike.

Mund të kryhet edhe analiza kompiuterike e imazheve hapësinorë duke përdorur metodat standard, përfshirë edhe paketën e softuerëve LESSA (Lineament Extraction and Stripe Statistical Analysis- Analiza Statistikore e Nxjerrjes dhe Fshirjes së Tipareve) për të ndërtuar skemën e strukturale me prishjet tektonike dhe blloqet në zonë (Fig. 3).

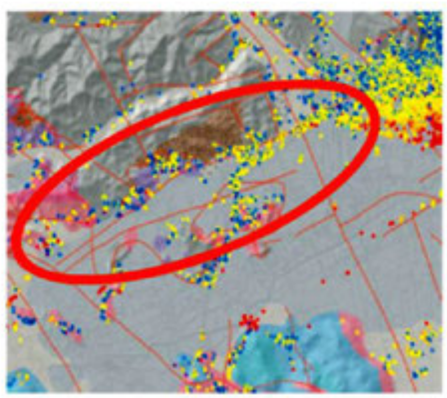

Fig. 3.Vlerësimi fushor i zhvendosjeve të zbuluara nga PSINSAR
(Geological Survey of Slovenia, 2008-2009)

Bëhet lidhja e imazhit hapësinor me hartat ekzistuese topografie, gjeologjike dhe gjeofizike për realizimin e interpretimit të përbashkët. Për këtë, mblidhen të gjitha të dhënat ekzistuese gjeologjike, gjeofizike dhe gjeodezike për zonën, si harta topografike (e detyrueshme), harta litologjike lidhur me llojet e formacioneve në zonë dhe vetitë e tyre fiziko-mekanike, harta gjeologjike dhe gjeofizike dhe prerjet përkatëse, etj. Kryhet analiza paraprake e të dhënave të disponueshme geologjike e gjeofizike, sepse ato lejojnë të shikohet në thellësi të strukturës si edhe të zbulohen rrëshqitjet "që flejnë" , të cilat në ndonjë ditë mund të shfaqen në sipërfaqe. Krijohet "portretit fotografik i rrëshqitjes" për zonat e pritshme për rrëshqitje, të cilët japin ndihmesë në zbulimin e veçorive që mund të pasqyrohen në imazhet hapësinore, në lidhje me strukturat gjeologjike të njohura sipas të dhënave gjeologjike dhe gjeofizike, si edhe për formulimin e kriterit për verifikimin e modelit. Përgatiten harta kompiuterike 3D të fushës së treguesve.

Për çdo shkallë studimi përcaktohen treguesit kryesorë për interpretimin, si edhe saktësohen stina, tipi i imazheve, zona e spektrit, nën të cilët shfaqën më mirë tregue sit. Dy tipe treguesisht merren në konsideratë: treguesit lidhur më strukturën në thellësi, si edhe treguesit e drejtpërsëdrejtë të rrëshqitjes së mundëshme. Për ngjarjet gjeologjike duhen përcatuar treguesit parimorë: prishjet tektonike, shënjat e rrëshqitjeve të vjetra dhe të ortekëve, lëvizjet e shpateve. Gjatë analizës vizuale të imazheve kihen parasysh parametrat e më poshtëm: skarpata e rrëshqitjes dhe të erozionit, "dehja e vegjetaciont" (pozicioni jo normal i pemëve, shkurreve, etj.), lokalizimi karakteristik i burimeve lidhur me elementët e relievit ("lumenjtë e barit" që markojnë zonat e truallit me lagështi), zhvendosja karakteristike e kufinjve gjeologjikë, etj.

Bazuar në rezultatet e kësaj faze dallohen shpatet potencialisht të rrezikuar dhe klasifikohet niveli i rrezishmërisë së tyre.

Studimi i detajuar i shpateve dhe i rrëshqitjeve konsiderohet se ka një rëndësi si të shtyllës kurrizore. **Metodat gjeofizike** përfaqësojnë pjesën më të rëndësishme e studimeve komplekse multi disiplinore. Në kompleksin gjeofizik bëjnë pjesë:

a) Mikrorilevimi magnetometrik për evidentimin e fillimit të veprimtarisë së rrëshqitjes, në nivelet ende të pavrojtueshme vizualisht në sipërfaqen e tokës.

b) Tomografia gjeoelektrike e realizuar me sondime elektrike vertikale ose me prerjen reale sipas profilimeve të gradientit të mesëm me skema të shumfishta. Krahas vlerësohet edhe anizotropia elektrike e trupit rrëshqitës dhe e shkëmbinjve rrënjësore.

c) Tomografia sizmike e valëve gjatësore dhe tërthore, me frekuencë të lartë.

d) Vrojtimet dhe monitorimi i emisionit sizmik të proceseve të deformmit brënda strukturës të rrëshqitjeve potencialisht të rrezikshme përfaqësojnë metodikën më të rëndësishme të studimit monitorues të shpateve.

e) Studimi gjeofizik i shpimeve (karotazhi elektrik, radioaktiv dhe zanor) për të studiuar trupin e rrëshqitjes dhe shkëmbinjtë rrënjësorë.

i) Inklinometria për të vlerësuar pjerësimin e puseve të vrojtimit me kohën në procesin e monitorimit të rrëshqitjeve.

j) Vrojtimi i deformimeve të brëndëshme të trupit të rrëshqitës.

k) Nxjerrja e kampioneve nga trupi rrëshqitës dhe shkëmbinjtë rrënjësorë, për të kryer analizat për përcaktimin e vetive fiziko-mekanike, përcaktime mineralogjike, petrografike të shlifeve, etj.

Veç të tjerash, punimet komplekse gjeofizike për kontrollin e vetive fiziko mekanike të truallit dhe të shkëmbinjve, në kuadrin e vlerësimit të qëndrueshmërisë së shpateve kanë si qëllim kryesor edhe vendosjen e reperëve – gjeofizikë, krahas atyre gjeodezikë, në rrëshqitjet aktive, për të siguruar monitorimin e tyre. Mundësitë që krijojnë metodat gjeofizike për zgjidhjen e problemeve të përcaktuara varet kryesisht nga modeli fiziko-gjeologjik i rrëshqitjes.

Shumë metoda gjeofizike janë përdorur për kontrollin e shpateve dhe për të zbuluar heterogjenitetet formacionale, kufinjtë dhe vetitë e masivëve shkëmborë. Vitet e fundit, shumë nga këto metoda kanë pësuar ndryshime të mëdha.

Sizmika

Metoda kryesore e përdorur është *metoda sizmike e valëve të thyera* (Stoethzner; Telford et. al.; Williams and Pratt, Bruno; Kurahashi et. al, Frashëri A. 2005, Bushati S. etj. 2008). Zhvillim i mëtejshëm e metodave sizmike të zbatuara për kontrollin e shpateve ka qënë realizimi i *tomografisë sizmike*, matjet e anizotropisë së shkëmbinjve, dobësimi dhe përthithja e valë ve (Luijk; Pyrak-Nolte and Shiau, Frashëri A. 2005, Bushati S. etj. 2008).

Kur fillojnë lëvizjet e vogla përgjatë rrafsheve të rrëshqijes, madje përpara sesa rezultatet e këtyre lëvizjeve të shfaqen në sipërfaqen e Tokës, ato shkaktojnë disa "*zhurma*" dhe "*murmuritje*". Prandaj, aktualisht, në kompleks me tomografinë sizmike zbatohet edhe metoda e e*kspozimit t*ë *miksosizmave me frekuencë të ulët* për studimin ë zonave të rrëshqitjeve. Kjo metodë jep të dhëna për studimin e strukturës së prishjeve tektonike dhe të shkallës së verimtarisë së tyre (Gorbatikov A.V., 2005, Russian Federation patent №2271554, aplikimi №20051083620) dhe,si një metodë sizmike e detajuar, hartografon dhe ekzaminohen në detaje heterogjenitetet vertikale dhe horizontale brenda trupit të rrëshqitjes. Metoda është analoge me atë të vrojtimeve sizmike, veçse si sinjal për sondim përdoren valet sizmike sipërfaqësore të frekuencës së ulët të truallit së Tokës, të natyrës së valëve sipërfaqësore të mikrosizmave Rayleigh's. Metoda bazohet në mundësinë e heterogjeniteteve të shpejtësiore së kores së Tokës për të ndryshuar spektrin e fushës së valëve mikro-sizmike. Në sipërfaqen e Tokës mbi heterogjenitete të frekuencës së lartë vrojtohet zvogëlim i amplitudave spektrale për frekuencën e dhënë (*f*), ndërsa amplitudat zmadhohen mbi heterogjenitete te fekuencës së ulët. Frekuenca (*f*) *i* përgjigjet heterogjeniteteve të thellësisë H dhe shpejtësisë të modës bazë të valëve të Rayleigh [$V_R(f)$]: $H=0.5V_R(f)/f$. Qëndrueshmëria e matjeve bazohet në investigimin e rezultateve të vetive statistikore të mikro-sizmave. Teknologjia e matjeve të kujton sondimet magnetotelurike, por shfrytëzohet fusha e zhurmave mekanike në vend të fushës elektromagnetike. Metoda është e aftë të lejojë ndërtimin e imazheve 3D të profileve për objekteve gjeologjike në shkallë krahasuese me atë të valëve sizmike. Janë veçanërissht efektive veçoritë e rezolucionit të kësaj metode, e cila lejon të gjenden objektet e heterogjeniteteve anësore.

Zbatimi i metodës është me kosto të ulët, më të ulët sesa kosto e vrojtimeve sizmike standard për të njejtën rezolucion në thellësi. Kjo metodë nuk kërkon përdorimin e një rrjeti multi-pikash të stacioneve sizmike që punojnë të sinkronizuar. Metoda mund të pajiset me aparaturëve që punojnë me parimin "nga pika në pikë". Punimet në terren kryhen me paisje të ndërtuara posaçërisht për realizimin praktik të vrojtimeve me këtë metodë. Këto pajisje përfshijnë stacion sizmik të kompiuterizuar dhe një bashkësi të simomarrsave që mbulojnë diapazonet frekuanciale 0.5÷15 Hz dhe 0.03÷15 Hz. Dhe 500-4000 Hz. Sonda realizon vrojtimin tre komponentësh të emisionit sizmik. Në procesin e përpunimit të të dhënave merren parasysh edhe kushtet klimatike, proceset atmosferikë dhe sizmicitetin krahinor. Për këto vrojtme duhet patur në konsideratë koha e leximit e sistemit. Për të veçuar

diapazonet frekuenciale të zhurmave sizmike dhe sizmo akustike të shkaktuara nga njerëzit nga ato natyrale duhen dalluar parametrat statistikohe të zhurmave sizmike dhe sizmo-ukustike. Procedura e përpunimit të të dhënave përshtatet për kohën reale të prognozimit të gjendjes korente të proceseve deformuese që zhvillohen në brëndësi të rrëshqitjes. Informacioni lidhur me kushtet e shkëputjes së sipërfaqes (rrafshit të rrëshqtjes) përpunohet në mënyrë të vazhduar dhe paraqitet në ekranin e operatorit, krahas edhe treguesit të riskut të rrëshqitjes.

Elektrometria

Metodat elektromagnetike janë përdorur për kontrollin e qëndrueshmërisë së shpateve gjatë një periudhe të gjatë kohe (Bogoslovsky and Ogilvy, Frashëri A. 2005, Bushati B. etj. 2008). Përmirësimet e kohëve të fundit në pajisjet si edhe programet kompiuterike kanë krijuar kushtet për zbatimin e imazheve të rezistencës elektrike specifike të dukshme dhe tomografinë dy dhe tre përmasore (Dahlin and Bernstone, Li and Oldenburg, Loke and Barker, Frashëri A. 2005, Bushati B. et.. 2008, etj.).

Zhvillim i më tejshëm i metodave gjeoelektrike për kontrollin e rrëshqitjeve kanë qënë vrojtimet me gjeoradar (Coe et al.; Galgaro, Genevois), matjet me lazer (GeoDev SA Earth Technologies), video kamerat (Kin wah Leung).

Vrojtimi i deformacioneve

Krahas matejeve gjeofizike kryhen edhe matje të deformacioneve të sipërfaqes, kryesisht me anën e inklinometrave (Applied Geomechanics Inc.), dhe matjet me synim të përcaktimit të lagështirës të trupit rrëshqitës (Monitorimi në kohë reale me anën e sistemit aktiv të rrëshqitjeve, i zhvilluar nga Shërbimi Gjeologjik i U.S.A.).

Janë projektuar dhe ndëtuar përkulje-matës (flexion-matës) dy koordinatësh për matjen e deformimeve përkulëse të kolonave të puseve të shpuar në trupit të rrëshqitës. Sonda e përkulje-matësit kanë dy elementë elastikë të ndjejshëm, të lidhur në skemë urë për matjen e deformimeve sipas dy boshteve ortogonalë. Këto pajisje kanë karakteristikat: Hapi i matjes fillon nga çdo 1 cm, diapazoni i matjes (rrezja minimale e përkuljes) është 0,75 m, ndjejshmëria (rrezja maksimale e përkuljes) 30 m. Për të rritur përmbajtjen e informacionit e të dhënave të matjeve të kryera në rrëshqitjet, preferohet që të disponohen të dhëna për shpërndarjen e rrezeve të përkuljeve të lidhura me profile hapësinore.

Në shumë raste është përdorur një kombinim i disa metodave për të njëjtën zonë, pasi veçori të ndryshme të strukturës nëntokësore mund të zbulohet nga metoda të ndryshme (Anon, Bruno at al, the US Washington Park Station monitoring system, Frashëri A. 2005, Bushati S. etj. 2008).

Metodat gjeofizike që u përshkruan janë të frytshme për marrjen e të dhënave lidhur me vetitë e shkëmbinjve dhe të dherave, si edhe kufinjtë nëntokësorë midis formacioneve të ndryshme. Por sistemet vrojtuese moderne të sofistikuara synojnë në zbulimin e fillimit të lëvizjeve. Në disa raste, janë të afta të japin informacion lidhur edhe me lagështinë e shkëmbinjve në shpatet, d.m.th. të japin të dhëna për fillimin e lëvizjeve të mundëshme, në kushte të favorshme. Por, pikërisht fakti se vetëm në “kushte të favorshme” vrojtimet me këto metoda vazhdojnë me lëvizjen e më pasme të shkëmbinjve, ato jo për çdo rast japin informacion lidhur me parashikimin e sjelljes së rrëshqitjes. Kështu, “pika e zgjimit” në parim e metodave monitoruese, të cilat sot kryhen në rrëshqitjet kudo rreth botës, është

fakt se ajo aktualisht vetëm sa zgjidh detyrën e zbulimit të lëvizjes, në rastin më të mirë, në fillimin e saj, madje ndonjëherë kur lëvizja është në progres.

Klasifikimi i shpateve mund të bëhet duke i ndarë shpatet në tre kategori:

- Shpate të sigurtë dhe shpate me nivel ekstremal të ulët për probalilitetin e rrëshqitjeve,
- Shpate potencialisht të rrezikuar, dhe
- Shpate me rrezikshmëri të lartë.

5. ANALIZA E REZULTATEVE TË STUDIMIT GJEOFIZIK TË DISA RRËSHQITJEVE NË SHQIPËRI

Konkretizmi i studimit gjeofizik kompleks i rrëshqitjeve po bëhet nëpëmjet analizës së rezultateve të vrojtimeve në tre shëmbuj (Bushati S. etj. 2008, Dhame L., 1974, Frashëri A. etj. 1995, 1996, 1997-a, b, c, d, e, 1998 a, b, c, d, 1999 a, b, 2005 a, b, Luli M. 1989, Radovicka P. etj. 1976):

5.1. Rrëshqitja në Poravë

Rrëshqitja e Poravës ndodhet në shpatin jugor të liqenit, rreth 2.5 km në lindje të digës së hidrocentralit të Fierzes, në fshatin me të njëjtin emër (Foto 5, Fig. 4). Shkarjeve të mëdha në bregun e majtë të lumit Drin në fshatin e Poravës, u është kushtuar vëmendje e madhe qysh në periudhën e projektimit të veprës, sepse një rënie e saj mund të shkaktonte valë të rrezikshme për digën (Dhame L. 1974, Radovicka P. etj. 1976). Studimet e asaj periudhe kanë përfshire jo vetëm njohjen e detajuar gjeologjike të qëndrueshmërisë së brigjeve në përgjithësi dhe të rrëshqitjeve në veçanti. Ato përfshine edhe kalkulime komplekse të qëndrueshmërisë së shpatit me anën e modelimeve hidraulike. Për këtë është simuluar edhe rënia e trupit të rrëshqitjes së Poravës me shpejtesi të ndryshme, nga 5 deri 10 m/sek. Parametrat për llogaritjet ishin ato që rezultuan nga studimet gjeologjike të asaj kohe. Të gjitha ato studime çuan në përfundimin se duhej të mbilartësohej diga edhe për rreth 12 m mbi kuotën e përcaktuar fillimisht në projekt, në mënyrë që të shtohej siguria për rastet ekstreme.

Sipas të dhënave gjeologjike, të periudhës së projektimit të veprës, trupi rrëshqitës i Poravës ka patur masë rreth 34 milion m^3 (R. Hanku, 1977). Këto punime treguan se brekçe vullkanogjene gjysëm shkëmbore, që vendosen mbi diabazet, ndërtojne shpate që krijojnë problem për qëndrueshmëri, sidomos kur kanë edhe plane tektonike të përshtatshme për të dhënë rrëshqitje (Dhame L., Dhima N., 1974). Sipas këtij studimi, rezulton se trashësia e këtij formacioni luhatet nga 10 deri 105 metra (Fig. 5). Në pjesën më të madhe të zonës, rreshpe silicore-argjilore të kuqërremta, të shtresëzuara hollë, pjesërisht të rrudhosura dhe të coptuara, që kanë trashësi 20-30 metra, shtrihen në pjesën e sipërme të prerjes.

Është konstatuar se jashtë veprimtarisë tektonike dhe efektit direkt të pranisë së linjave tektonike do të ekzistonin vetëm rrëshqitje të vogla, të reja ose të riaktivizuara pranë derdhjes së përroit në Drin dhe shëmbje shpatore brënda shtrateve të përrenjve, por edhe këto të parëndësishme. Por, meqënëse në zonën e Poravës ka veprim tektonik shumë të zhvilluar, si zonë ndërmjet dy masivëve ultrabazikë të mëdhenj të Tropojës dhe Krrabit, ekziston edhe një sistem linjash tektonike me elemente shtrishmërie 290^{o}-300^{o} dhe këndrënie në VL 15^{o}-18^{o}, të cilat duke qënë brënda formacionit gjysëm shkëmbor brekçioz krijojnë kushte të favorshme për rrëshitje. Në atë periudhë është përfunduar "…kur liqeni të mbushet deri në nivelin 295m, blloku 1 bëhet me qëndrueshmeri kritike dhe rrëshqitja mund të ndodhë pjesë pjesë…." dhe "…mendojme që edhe në rastin më të disfavorshëm të mundësisë së rrëshqitjeve, në këto kushte (këndi i rënies i vogël 15^{o}-18^{o} dhe 70% e materialit nën kuoten 300 m), nuk paraqet problem" (Dhame L., Dhima N., 1974).

Analiza me imtësi e rezultateve të studimeve gjeologjike të viteve shtatëdhjetë, dhe krahasimi i tyre me të dhënat e marra gjatë ristudimit të kësaj rrëshqitje në vitin 1996, d.m.th. mbas mbi 20 vjet, krijoi mundësinë për të vlerësuar dinamikën e zhvillimit të rrëshqitjes pas mbushjes së liqenit me ujë dhe ndikimin e dinamikës së uljeve dhe ngritjeve të nivelit të ujit në liqen, gjatë të gjithë kësaj periudhe.

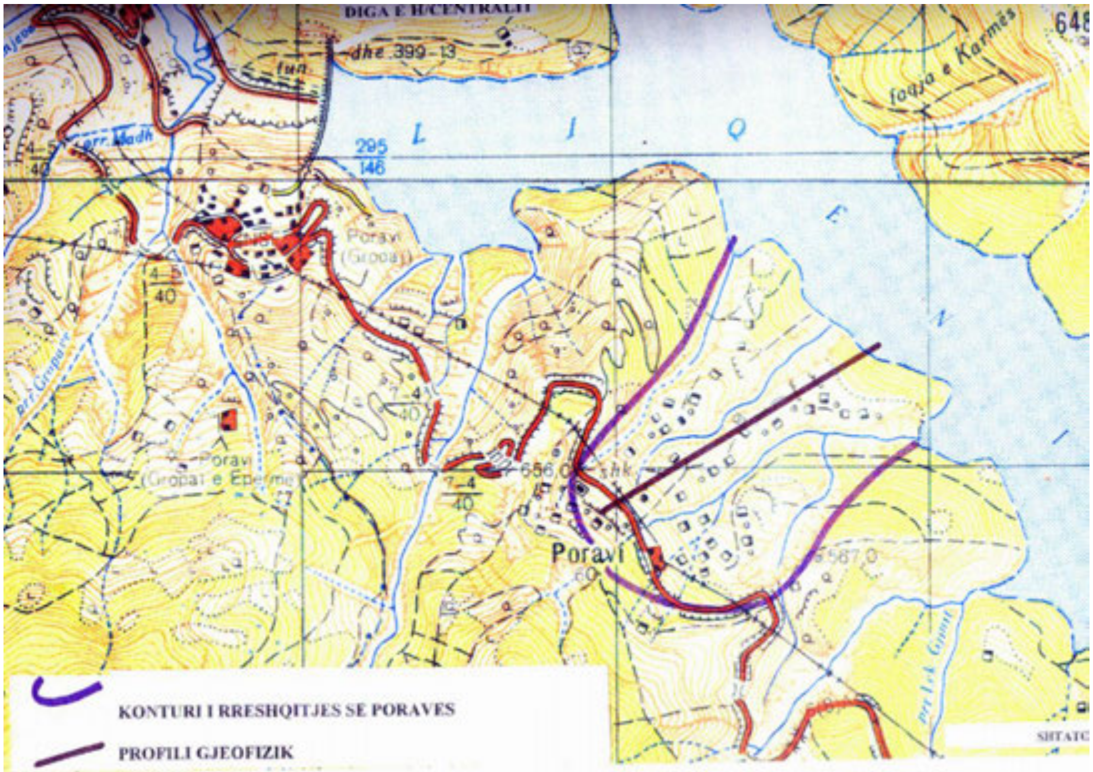

Fig. 4. Planimetria e rrëshqitjes në Poravë.

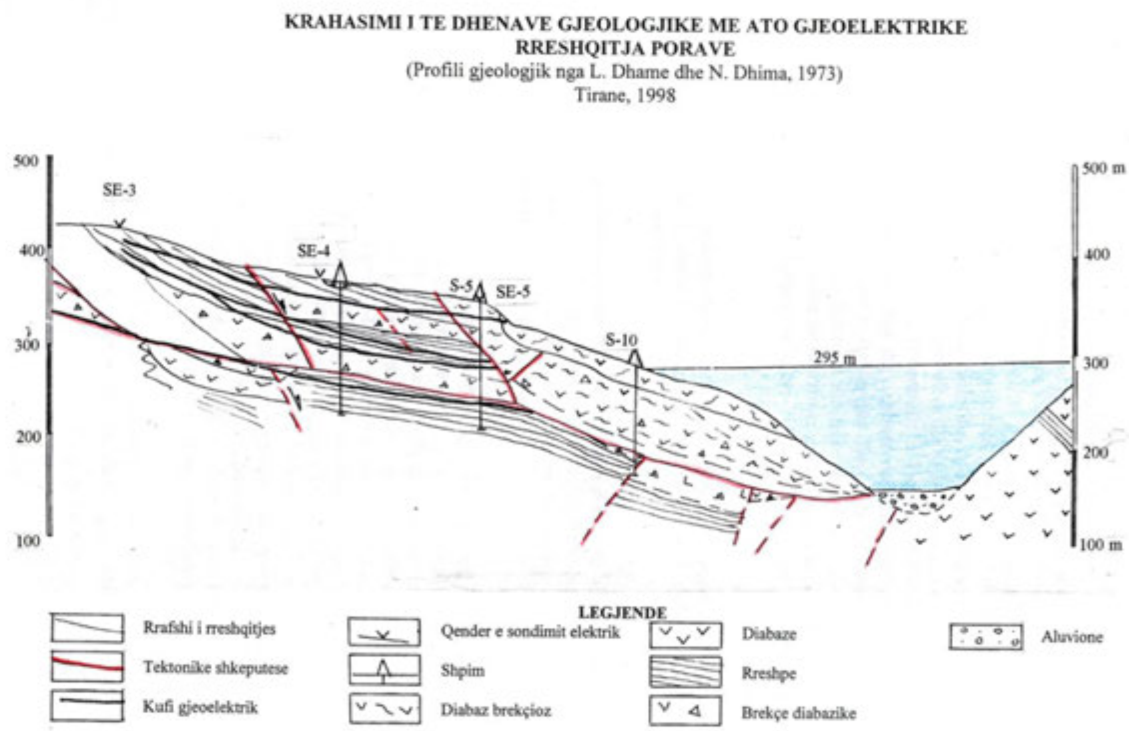

Fig. 5. Prerje gjeologjike e rrëshqitjes në Poravë (Sipas L. Dhame, N. Dhima, 1974).

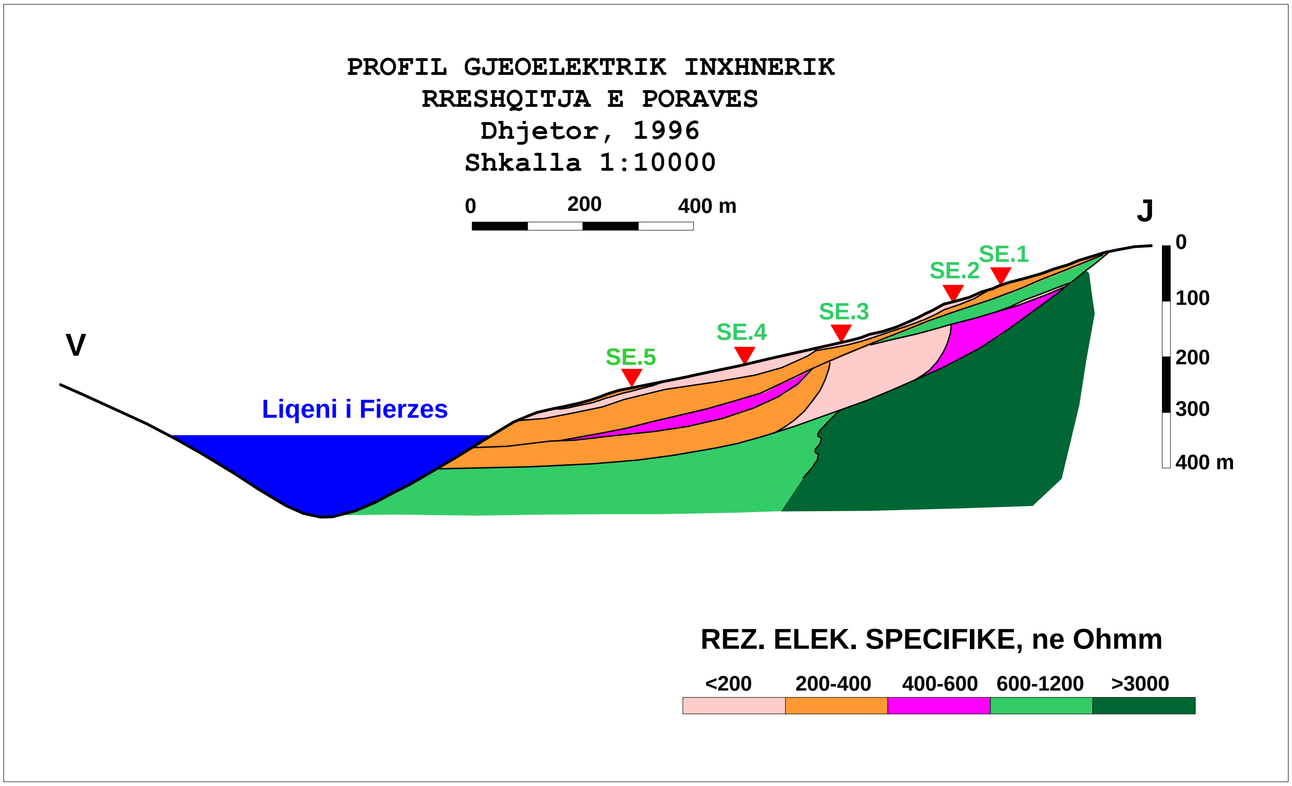

Fig. 6. Prerje gjeoelektrike inxhinjerike e rrëshqitjes në Poravë.

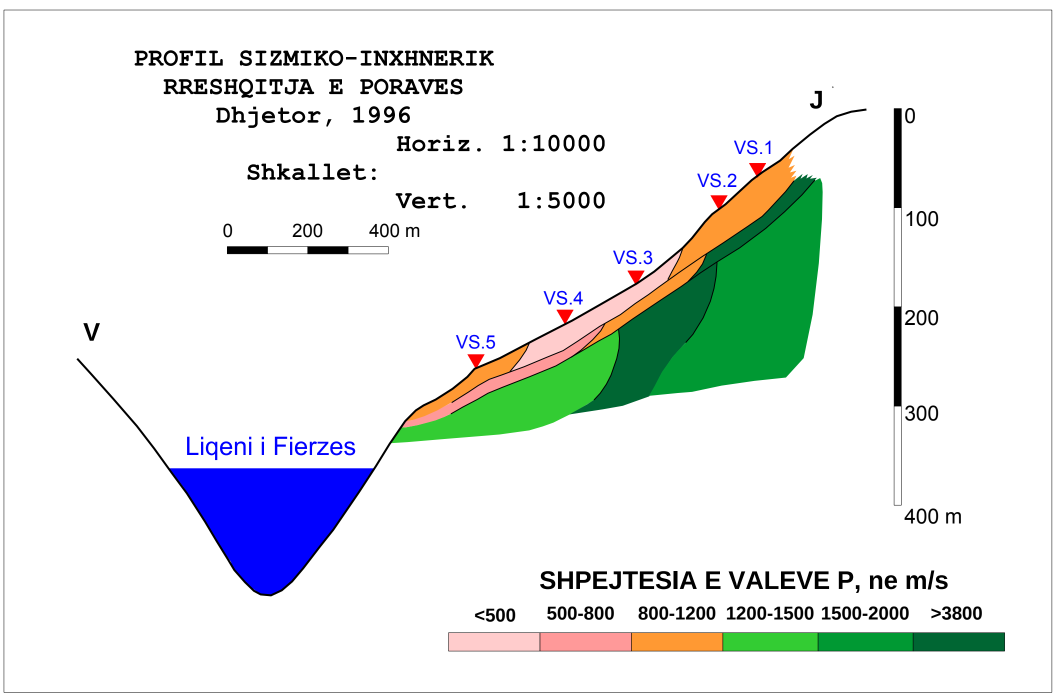

Fig. 7. Prerje sizmo inxhinjerike e rrëshqitjes në Poravë.

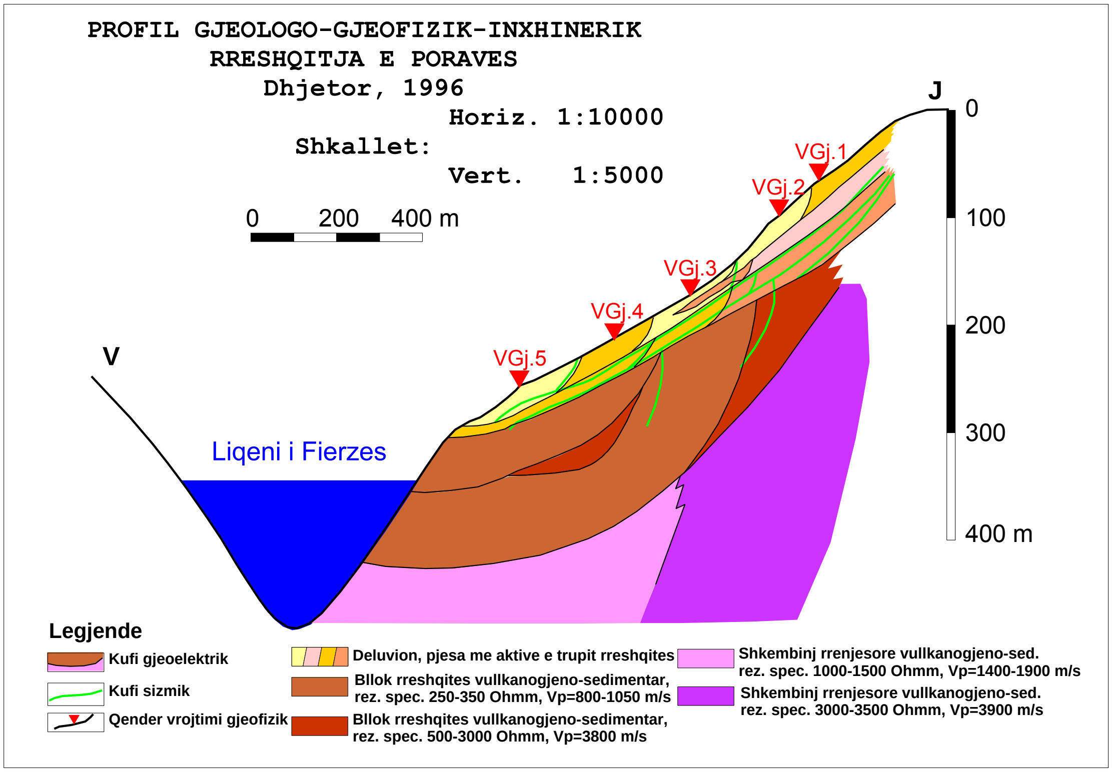

Fig. 8. Prerje komplekse gjeologo-gjeofizike në rrëshqitjen në Poravë.

Në vitin 1996, u vendosën reperët e parë gjeofizike për ta studiuar atë dhe që përbëjnë element të rëndësishëm bashkëkohor për ta monitorizuar këtë rrëshqitje në të ardhmen.

Mbështetur në të dhënat e përftuara nga vrojtimet gjeofizike, në njohurite e detajuara gjeologjike ekzistuese për këtë zonë, si dhe të gjëndjes aktuale të rrëshqitjes së Poravës, është realizuar analiza e rezultateve të punimeve komplekse gjeofizike të kryera në vitin 1996.

Në fig. 6 paraqitet profili gjeolektrik i detajuar i rrëshqitjes së Poravës. Aty janë fiksuar dy kategori kufinjsh gjeoelektrikë. Kategoria e parë i takon kontaktit të poshtëm, në thellësi 140-160 m dhe i sipërmi 20 m thellë, të cilët ndajnë mjedise me veti elektrike të ndryshme. Kufiri i poshtëm është kryesori, i cili ndan trupin rrëshqitës nga shkëmbinjtë rrënjësorë të serisë vullkanogjeno-sedimentare. Ai është reperi që përvijon qartë strukturën e trupit të rrëshqitjes, në kontakt me shkëmbinjtë vullkanogjeno-sedimentarë. Kufiri i sipërm ndan trupin e rrëshqitjes në dy shtresa të mëdha. Pjesa më e sipërme e trupit lidhet me depozitimet deluviale-eluviale. Kjo pjesë është në lëvizje të vazhdueshme intensive, duke shkaktuar çarjet e të gjitha shtëpive të fshatit Poravë (Foto 7). Nga këta reperë gjeoelektrikë, së pari, përcaktohet konfiguracioni i strukturës së rrëshqitjes në shkëmbinjtë e prerjes vullkanogjene sendimentare, të cilët kanë vlera relativisht të ulta deri mesatare të rezistencës elektrike specifike (200-1000 Ohmm), si rrjedhojë e ndikimit të veprimit të rrëshqitjes. Ndërsa shkëmbinjtë vullkanogjene të ndodhur nën tërë këtë rrëshqitje masive, përfaqësohen me vlera të larta të rezistencës elektrike specifike 3000-3800 Ohmm në sektorin më të largët të profilit nga liqeni dhe me vlera 1200-1400 Ohmm në atë sektor që

ndodhet pranë bregut të liqenit artificial të H/centralit të Fierzës. Pjesa më e sipërme e trupit të kësaj rrëshqitje, e përfaqësuar nga depozitimet deluviale-eluviale si edhe nga pjesa

shkëmbore më e shkatërruar e trupit të rrëshqitjes dhe e cila sot është shumë aktive, paraqitet me vlera tepër të ulta të rezistencës elektrike specifike 120-500 Ohmm. Ky aktivitet, siç u tregua më sipër, pasqyrohet në dëmtimet e vazhdueshme të shtëpive dhe të objekteve të ndryshme të fshatit Poravë, si edhe nivelet e ndryshme të terracave të rrëshqitjes në sipërfaqen e tokës. Nga prerja e fig. 6 duket se kufinjtë gjeoelektrike janë plotësisht paralelë me kufinjtë e dhënë nga studimi gjeologjik i viteve shtatëdhjetë. Por në veçanti, shfaqen kufinjtë gjeoelektrikë të siperm, pranë sipërfaqes së tokës.

Heterogjenitet e dukshme gjeoelektrike gjatë profilit, shprehin përbërjen bllokore që ka në tërësi kjo rreshqitje, siç ka rezultuar edhe nga punimet gjeologjike të kohës së projektimit të hidrocentralit. Kjo strukturë e trupit të rrëshqitjes krijon mundësinë që të gjykohet cilësisht edhe për ecurinë e kësaj rrëshqitje me kohën.

Në fig. 7 paraqitet prerja sizmike-inxhinierike e të njëjtit profil me atë gjeoelektrik. Në këtë veçohet mjaft mirë pjesa më e sipërme e trupit të kësaj rrëshqitje, pra zona me thellësi deri 25 m. Kjo prerje ka dallueshmëri mjaft të qartë në të dy parametrat sizmike, si në shpejtësinë e valëve gjatësore ashtu dhe në ato tërthore. Depozitimet deluviale fiksohen me vlera të Vp=400-1200 m/s dhe me Vs=150-450 m/s, ndërsa depozitimet eluviale dhe shkëmbinjtë vullkanogjenë të pjesës më të sipërme të ndodhura mbi rrafshin rrëshqites kanë Vp=800-3880 m/s dhe Vs=350-800 m/s. Depozitimet vullkanogjene të shtrira nën rrafshin e parë rrëshqites fiksohen me Vp=1400-3800m/s dhe Vs=600-1500 m/s. Kjo prerje përvijon të njëjtët elementë si edhe reperët gjeoelektrike dhe me të dhënat e saj krijoi mundësinë që të vlerësohen parametrat fiziko-mekanikë të dherave dhe të shkëmbinjve. Kategoria e dytë e kufinjve lidhet me ndryshimet dhe me heterogjenitetet në rënie të trupit të rrëshqitjes, të cilat e ndajnë atë në blloqe.

Nga parametrat sizmikë është bërë vlerësimi i karakteristikave fiziko-mekanike të shkëmbinjve të këtij trupi rrëshqitës në shtrirje dhe në thellësi, të cilat paraqiten në pasqyrën Nr. 1.

Vetitë fiziko-mekanike të trupit të rreshqitjes së Poravës dhe shkëmbinjve rrënjësorë, sipas të dhënave të kontrollit in-situ sizmik

Pasqyra Nr. 1

Rresh-qitja	Shtresa Nr	Shtresa h në m.	Vp m/s	Vs m/s	ρ, g/cm^3	Koef. Puassonit.. ν	Moduli dinamik i elasticitetit x10^5 KG/cm^2 Sipas Vp	Moduli dinamik i elasticitetit x10^5 KG/cm^2 Sipas Vs	Moduli i ngurrte-sise G, x10^5 KG/cm^2	Moduli Bulkut K, x10^5 KG/cm^2	Shtypja vellimo-re Sh, x10^5 KG/cm^2
Poravë	1	2.9	400	200	1.53	0.33	0.02	0.02	0.006	0.02	0.02
	2	6.4	600	400	1.44	0.1	0.06	0.o6	0.03	0.02	0.02
	3	11.5	1050	580	1.92	0.28	0.17	0.17	0.07	0.13	0.13
	4		1760	940	2.15	0.30	0.45	0.45	0.17	0.38	0.38

Dendësia e shtresave të ndryshme është llogaritur sipas madhësive të shpejtësive të valëve sizmike, duke përdorur formula të njohura. Meqenë se këto formula janë statistikore, vlerat e vogla të dendësisë së shtresës së parë, madje edhe të dytë kanë rezultuar me të vogla sesa janë zakonisht në natyrë. Prandaj edhe madhësitë e vetive të tjera fiziko-mekanike të tabelës së mësipërme për këto dy shtresa duhen marrë si nivele më të poshtme. Gjithësesi, shpejtësitë shumë të vogla të valëve sizmike gjatësore dhe veçanërisht ato tërthore dëshmojnë pa mëdyshje për shtresa të shkrifta poroze të trupit të rrëshqitjes.

Nga studimi i mikrozhurmave sizmike natyrore vërehen pamje të ndryshme të regjistrimeve në të gjitha qëndrat e vrojtimeve, pra ekzistojnë intesitete të ndryeshme të tyre. Kështu, aty ku mikrozhurmat kanë intesitet maksimal ndodhen zonat më dinamike të këtij masivi rrëshqitës, që janë mjaft të dukshme dhe të pranishme në fshatin e Poravës, me çarjen dhe dëmtimin e madh të shumë shtëpive, si edhe me lëvizjen disa metra (2-4 m) të parcelave të tokës bujqësore, të shpateve, etj, brënda një periudhe 2-3 vjecare (1994-1996).

Në prerjen komplekse gjeofizike-inxhinierike (Fig. 8), vërehet një përputhje mjaft e mirë e rezultateve të sondimeve elektrike me ato të vrojtimeve sizmike, të përdorura për studimin e kësaj rrëshqitje. Gjithashtu në këtë prerje realizohet fiksimi i plotë i të dy rrafsheve të rrëshqitjes, natyra e tyre si dhe gjendja dhe përbërja e të dy pjeseve të trupit të rrëshqitjes. Kështu pjesa më e sipërme e kësaj rrëshqitje përbëhet kryesisht nga depozitime deluviale-eluviale dhe shkëmbinj të shkatërruar, e cila arrin deri në thellësinë rreth 20 m, duke qënë mbi rrafshin e parë tepër dinamik të kësaj zone. Nën të shtrihet masivi i shkëmbinjve vullkanogjeno-rreshporë që ndodhet mbi rrafshin më të thellë të rrëshqitjes së Poravës (100-160 m). Ky rrafsh është i fiksuar qartë dhe ndan trupin rrëshqitës me trajtë bllokore nga shkëmbinjtë vullkanogjeno-reshporë të paprekur nga rrëshqitja dhe të ndodhur nën të.

Duke u bazuar në rezultatet e deri tanishme të vrojtimeve komplekse gjeofizike për rrëshqitjen e Poravës rezulton se ekzistojnë ndryshime, që kanë ndodhur në pjesën e sipërme të trupit të rrëshqitjes së Poravës, gjatë periudhës mbi 20 vjeçare që ka kaluar nga koha e ndërtimit të hidrocentralit dhe e mbushjes së liqenit me ujë, si rrjedhojë, në rradhë të parë e aktivizimit të pjesëve më të thella të trupit të rrëshqitjes nën veprimin e ujit të liqenit mbi masën e këtij trupi. Sado të vogël, ka patur ndikim edhe seria e tërmeteve të gjeneruar nga mbushja e liqenit të Fierzës me ujë, si edhe zhvillimet e neotektonikës.

Rezultatet e vrojtimeve gjeofizike të kryera, ashtu si edhe ato gjeologjike, lejojnë gjithashtu se mund të mendohet që nuk mund të ndodhë rënia e menjehëreshme dhe me të njëjtën shpejtësi e të gjithë trupit të rrëshqitës, pasi ai është i ndarë në blloqe dhe mund të bjerë pjesë pas pjesë. Përgjigja e ketij problemi mund e jepet e sigurtë vetëm pasi të studiohet dinamika e rrëshqitjes, duke kryer monitorimin e saj sistematik. Ky problem bëhet aq më tepër i prefët, kur shtrohet pyetja për sjelljen e trupit të rrëshqitjes gjatë tërmeteve të fuqishme.

5.2. Rrëshqitja në Ragam, Vau i Dejës

Rrëshqitja ndodhet në brigjet e liqenit të Vaut të Dejës (Fig. 9, 10, Foto 1, 2). Ajo zhvillohet në formacionin ofiolitik të përfaqësuar nga shkëmbinj të serpentinizuar (Foto 3, 4).

Kjo rreshqitje është vrojtuar për herë të parë në vitin 1989 dhe është studiuar nga një grup specialistesh (Luli M., 1989). Në atë kohë, sipas relacionit të tyre, ajo përfaqësonte një rrjedhje sipërfaqësore deluvionesh, e vlerësuar si e parëndësishme (Fig. 10). Sipërfaqja e trupit të rrëshqitjes në atë kohë ishte 0.08 km^2.

Trupi i rrëshqitjes përfaqëson një masë të madhe serpentinitesh të përajruar dhe të shkatërruar, të mbuluar nga trashësi e vogël deluvionesh. Ajo është zhvilluar në masë të dukshme këto gjashtë vjetët e fundit. Në vitin 1996 sipërfaqja e trupit të rrëshqitjes arriti në 0.4 km^2.

Balli i dukshëm i trupit të rrëshqitjes shtrihet gjatë bregut të liqenit. Ai ka formen e një skarpate 2-3 metra të lartë të serpentiniteve të shkatërruar, të shistezuar dhe vende vende të milonitizuar (Foto 3, 4).

Në këtë rrëshqitje dallohen tre nivele sipërfaqësore shkëputjeje:

- i pari rreth 35-45 m larg bregut, me një zhvendosje horizontale rreth 2 m.
- i dyti rreth 70-90 m larg bregut, me shkëputje vertikale me amplitudë rreth 2 metra.
- i treti rreth 115-130 m larg bregut. Ky është niveli më i ri dhe me amplitudë më të vogël.

Profilet gjeofizike, të kryer në vitin 1996 profili terthor dhe në vitin 1998 ai gjatësor, kanë lejuar të studiohet mirë trupi i rrëshqitjes (Fig. 11, 12). Në prerjet komplekse gjeofiziko-inxhinjerike tërthore dhe gjatësore të trupit të rrëshqitjes, të treguar në fig. 3.9 duket se trup është i ndarë nga dy rrafshe kryesore të rrëshqitjes. Këto rrafshe janë të copëtuar. Rrafshi i parë ndodhet në thellësinë reth 5-7 m, ndërsa rrafshi i dytë arrin në thellësinë maksimale deri 22 m. Pjesa më e poshtme e rrafshit të dytë kontakton direkt me liqenin, nën nivelin e ujit. Në këtë mënyrë, trupi i rrëshqitjes ka pamje bllokore. Vetitë fiziko-mekanike të masës shkëmbore të trupit të rrëshqitjes janë shumë më të ulta sesa ato të shkëmbinjve rrënjësorë të paprekur nga rrëshqitja Pasqyra Nr. 2, 3.

Siç duket nga pasqyra 2 dhe 3, trupin e rrëshqitjes e formojnë katër shtresa me veti fiziko-mekanike të ndryshme. Shtresa e parë janë deluvionet. Shtresa e dytë dhe e katërt përfaqësojnë serpentinitë të shkatërruar dhe të dërmuar. Shtresa e tretë midis tyre karakterizohet nga rezistencë elektrike specifike e ulët dhe shpejtësi e vogël e përhapjes së valëve sizmike. Ajo i korrespondon një shtrese serpentinitësh me klivazh dhe të çara ujëmbajtëse. Si edhe në rastin e rrëshqitjes së Poravës, madhësite e vetive fiziko-mekanike të tabelës së mësipërme për keto dy shtresa duhen marrë si nivele më të poshtme.

Gjithësesi, shpejtësitë shumë të vogla të valëve sizmike gjatësore dhe veçanërisht ato tërthore dëshmojne pa mëdyshme për shtresa të shkrifta poroze të trupit të rrëshqitjes.

Duke vendosur reperët gjeofizike, u krijuan mundësitë për të përdorur edhe parametrat gjeofizikë për të monitorizuar rrëshqitjen.

Dinamika e lëvizjes së trupit të rrëshqitjes është e shprehur edhe me veprimtarinë sizmo-akustike natyrore. Në fig. 13 jepen regjistrimet e veprimtarisë sizmo-akustike në rrëshqitjen e Ragamit. Në kanalet e gjeofonëve të vendour direkt mbi trupin e rrëshqitjes është qartësisht e ndjejshme veprimtaria sizmo-akustike e shkaktuar nga kjo lëvizje. Mikrolëkundjet në trupin e rrëshqitjes janë shumë intensive dhe me bandë të gjerë frekuenciale, ndërsa jashtë këtij trupi ky aktivitet mungon.

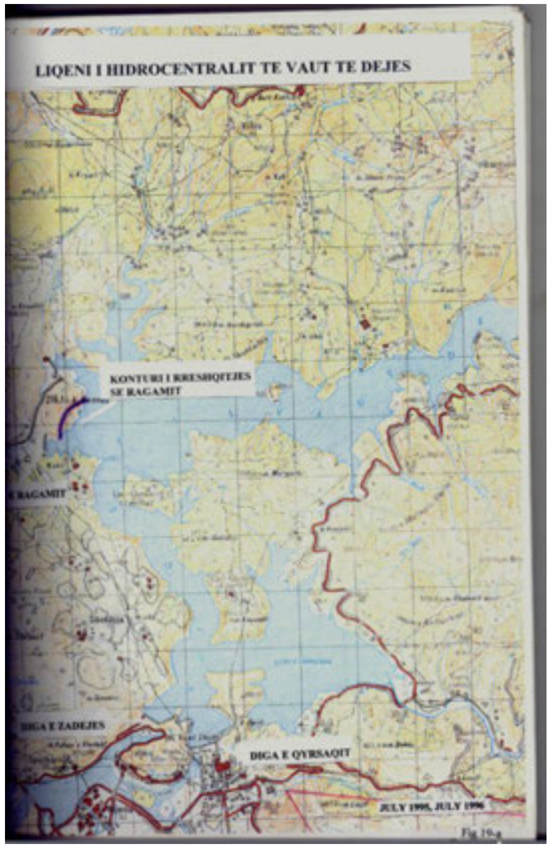

Fig. 9. Harta topografike e zonës së rrëshqitjes së Ragamit, Vau i Dejës.

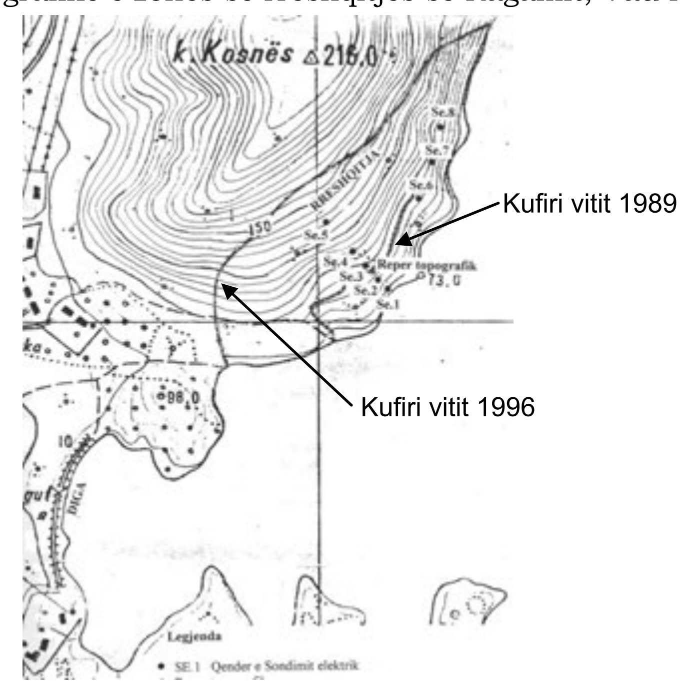

Fig. 10. Planimetria e rrëshqitjes së Ragamit, me vendvendosjen e qendrave të reperëve gjeofizikë.

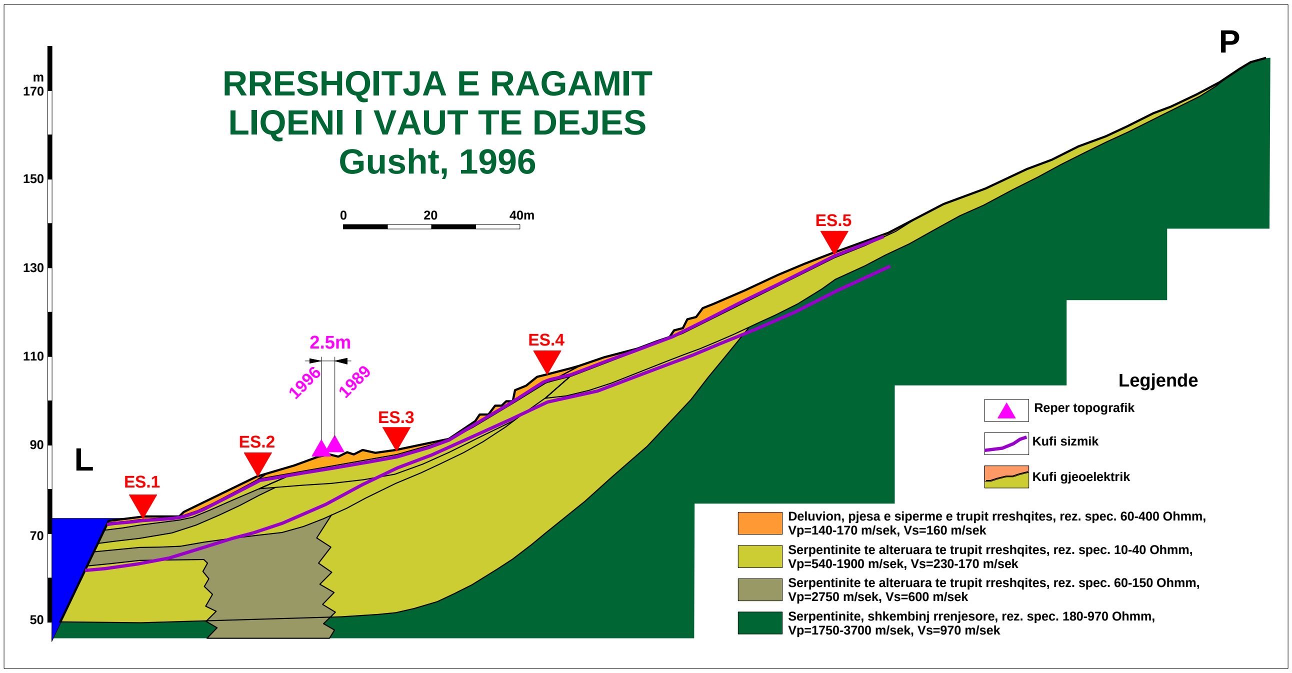

Fig. 11. Prerje komplekse gjeofizike tërthore në rrëshqitjen e Ragamit.

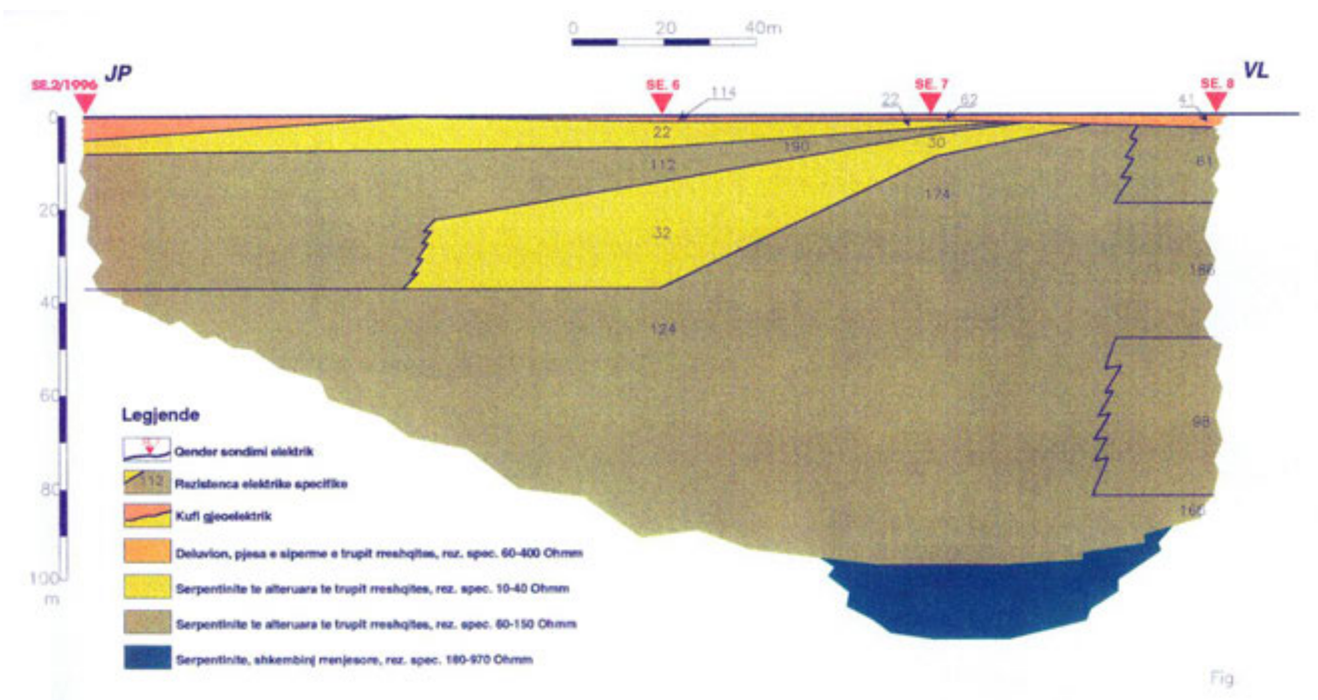

Fig. 12. Prerje komplekse gjeofizike gjatësore në rrëshqitjen e Ragamit.

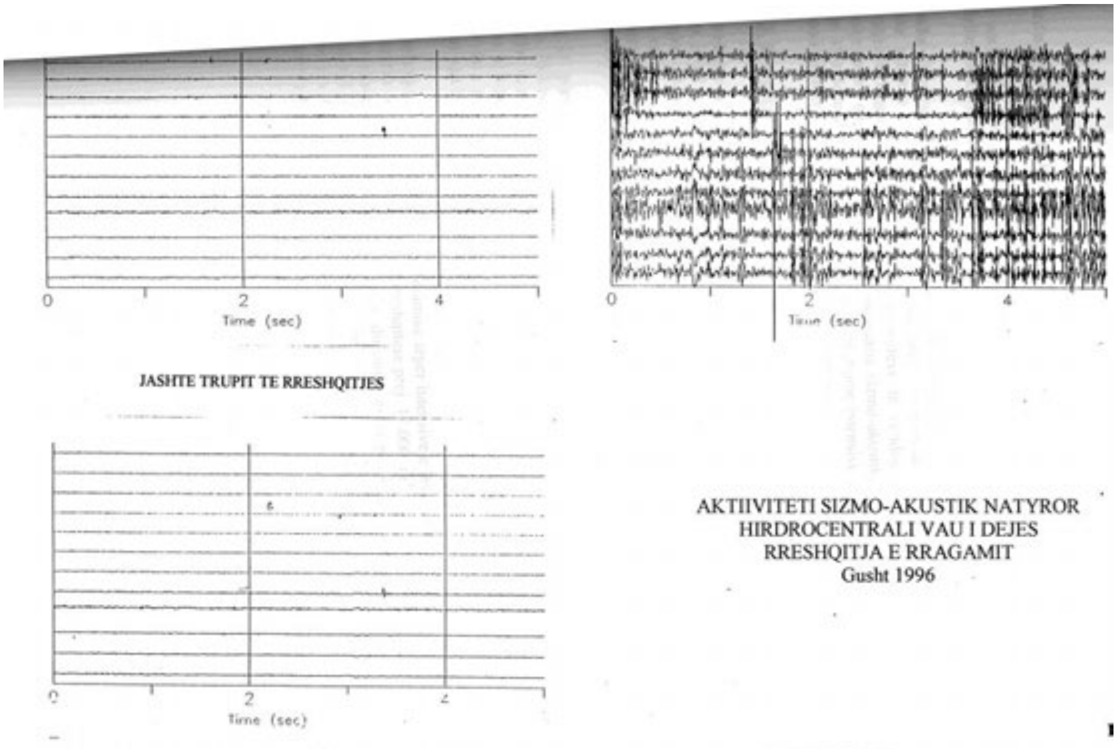

Fig. 13. Aktiviteti sizmo-akustik natyror në rrëshqitjen e Ragamit

Vetitë fizike të shkëmbinjve në zonën e rrëshqitjes

Pasqyra 2

<table>
<tr><th rowspan="2">Nr. shtresës</th><th rowspan="2">Trashësia në metra</th><th rowspan="2">Resistenca elektrike specifike në Ohmm</th><th rowspan="2">Dendësia, në g/cm³</th><th colspan="2">Shpejtësia e valëve, në m/sec</th><th rowspan="2">Litologjia</th></tr>
<tr><th>Vp</th><th>Vs</th></tr>
<tr><td colspan="7">TRUPI RRËSHQITËS</td></tr>
<tr><td>1</td><td>0.7</td><td>76.4</td><td>1.34</td><td>210</td><td>160</td><td>Deluvione</td></tr>
<tr><td>2</td><td>4.0</td><td>29.5</td><td>1.61</td><td>540</td><td>230</td><td>Serpentinite të shkatërruar</td></tr>
<tr><td>3</td><td>6.5</td><td rowspan="2">46.5</td><td>2.45</td><td>3700</td><td>680</td><td>Serpentinite ujëmbajtës</td></tr>
<tr><td>4</td><td>17.4</td><td></td><td>1500</td><td></td><td>Serpentinite të shkatërruar</td></tr>
<tr><td colspan="7">SHKËMBINTË RRËNJËSORË</td></tr>
<tr><td></td><td></td><td>485</td><td>2.56</td><td>3500</td><td>1920</td><td>Serpentinite</td></tr>
</table>

Vetitë mekanike të shkëmbinjve në zonën e rrëshqitjes

Pasqyra 3

Nr. shtre-sës	Koeficienti Puassonit	Moduli Dinamik i elasticitetit, E_d^s në *10^5 kg/cm^2	Moduli i ngurtësisë G, në *10^5 kg/cm^2	Shtypja vëllimore, σ, në *10^5 kg/cm^2	**Gjendja e shkëmbinjve**
TRUPI RRËSHQITËS					
1	0.35	0.00370	0.00140	0.00420	Shkëmb i butë
2	0.39	0.02413	0.00868	0.03630	Shkëmb i shkatërruar, i dërmuar
3	0.48	0.56586	0.19167	3.26503	Shkëmb me klivazh dhe të çara
4		0.26325	0.09608		Shkëmb i shkatërruar, i dërmuar
SHKËMBINJTË RRËNJËSORË					
	0.29	2.46271	0.96199	1.91408	Shkëmbinj kompaktë

5.3. Rrëshqitja në Banjë

Kjo rrëhqitje u krijua në kohën e hapjes së tunelit të derivacionit në hidrocentralin e Banjës (Fig. 14). Ajo u zhvillua gjatë gërmimeve në formacionet flishore të paleogjenit. Karakteristikë e prerjes flishore këtu është përmbajtja e shumë shtresave të trasha ranore, të cilat kanë rënie sipas relievit. Kjo rrëshqitje shkaktoi shkatërrimin e plotë të tunelit të derivacionit të ndërtuar deri në atë kohë.

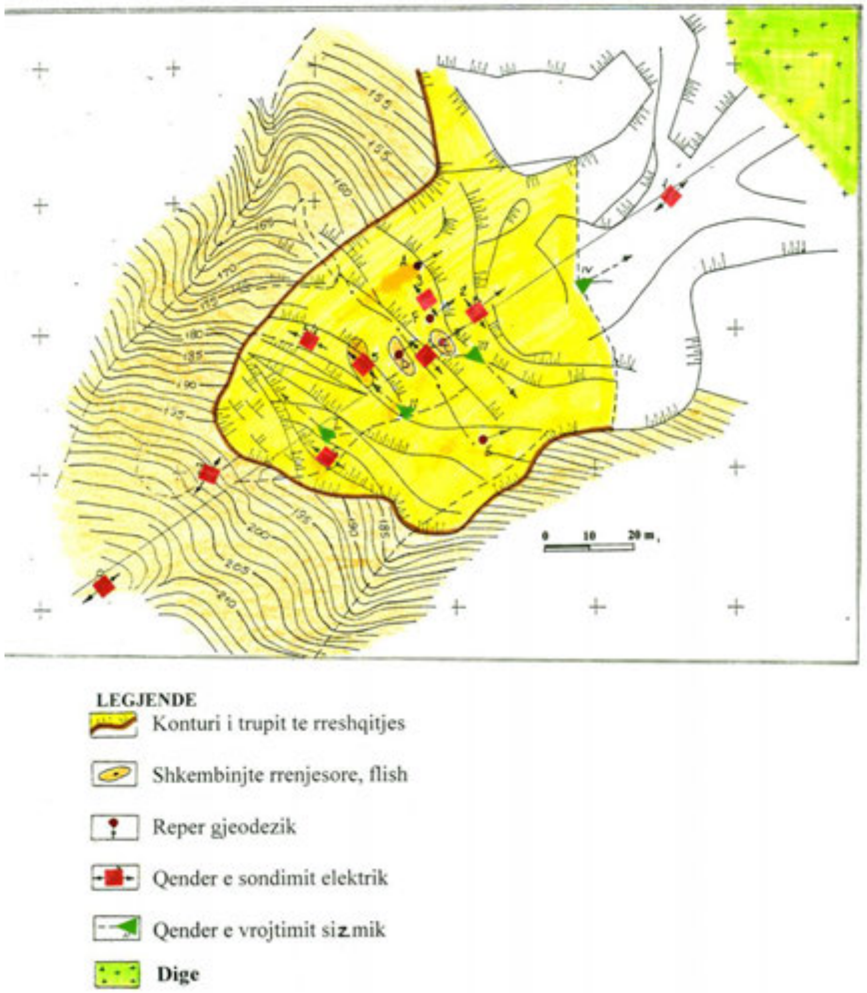

Fig. 14. Harta topografike e zonës së rrëshqitjes në Banjë, me vendvendosjen e qëndrave të reperëve gjeofizike (Kapllani L.).

Në fig. 15 paraqitet preja komplekse gjeofizike-inxhinjerike nëpër trupin e rrëshqitjes në Banjë. Thellësia maksimale e shtrirjes së rrafshit të rrëshqitjes është 22 metra, në qëndrën e profilit. Karakteristikat gjeoelektrike të trupit të rrëshqitjes janë shumë të dallueshme nga ato të formacionit flishor të ndodhur jashtë rrëshitjes. E njëjta tablo është edhe për shpejtësitë e përhapjes së valëve sizmike. Trupi i rrëshqitjes është mjaft heterogjen dhe i ndërtuar nga blloqe të ndryshme.

Kjo rrëshqitje u karakterizua nga një dinamike tepër intensive e lëvizjes së masës së trupit të rrëshqitjes. Për rreth një muaj, masa rrëshqitëse prej 17 000 m^3 u çvendos rreth 5-7 m. sipas vrojtimit të reperëve gjeodezike. Kjo dinamike është pasqyruar edhe në aktivitetin sizmoakustik natyror (fig. 16). Në këtë figurë, duket se brënda trupit të rrëshqites

mbizotërojnë lëkundje me frekuanca më të larta sesa jashtë tij. Mikrolëkundjet kanë amplitudë shumë herë më të lartë.

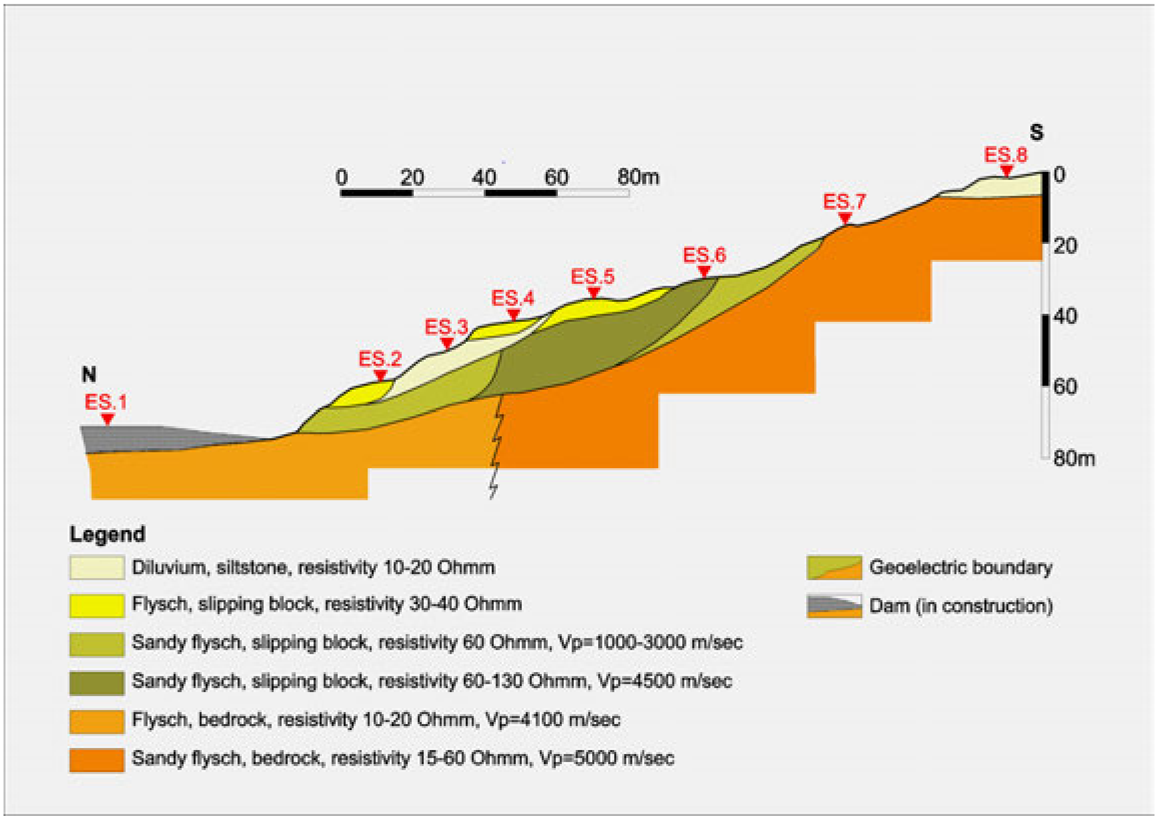

Fig. 15. Rezultatet e studimit gjeofizik në rrëshqitjen e Banjës (Kapllani L.).

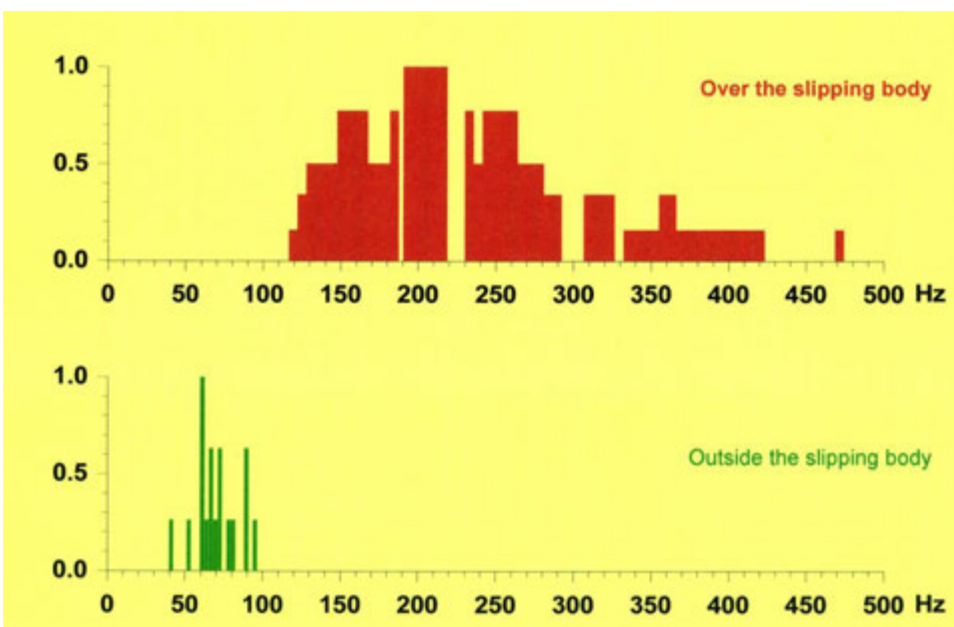

Fig. 16. Aktiviteti sizmo-akustik natyror në rrëshqitjen e Banjës (Kapllani L.).

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ALBANIAN GEOTECHNICAL SOCIETY
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SLOPE STABILITY AND LANDSLIDE INVESTIGATION AND MONITORING USING GEOPHYSICAL DATA

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1. Introduction

Albania represents a mountainus country and Albanides are represented geological structures with possibilities of instable slopes and landslide development.

Based on the geological formations and landslide body mass, can be present following landslide classification in Albania (Fig. 1.1):

- Instable slopes and intensive landslides developed in weathered bedrocks and in overburden bed at the lakeshores of hydropower plants.
- Instable slopes and intensive landslides developed in Oligocene flysch formation.
- Instable slopes and landslides developed in Neogene's molasses formations.
- Landslides developed in loose Quaternary deposits.
- Downfalls in the weathered rocks

Developing of new landslides or re-activation of the old ones is mainly due to construction works. Slope mass movements (landslides, debris flow, rock falls, rock slides, etc.) have become a big issue in recent years, especially after several casualties. Special constructions, such as hydrotechnical works, civil, industrial, urban and rural constructions and constructions in the infrastructure, particularly during last year's, as well as destroyed equilibrium in ecological systems through deforestation etc., all these events have contributed to landslide development. Landslides are located in the deluvial deposits,

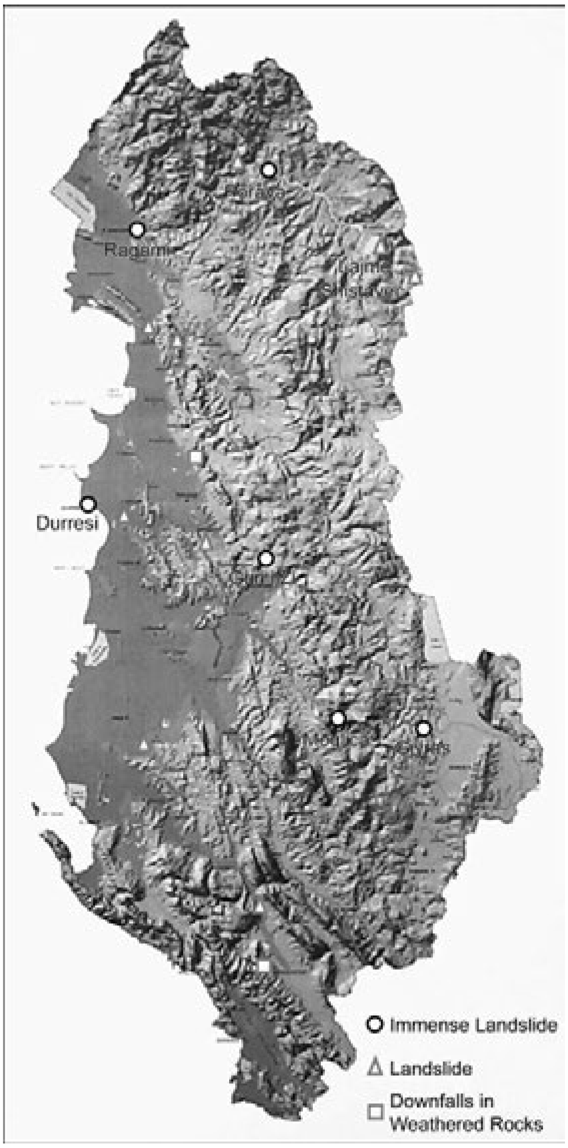


Fig.1.1. Landslides and rock downfalls in Albania.

and in the altered-bedrocks. The slipping bodies of some landslides have very big volume, more 50 than million cubic meters. The biggest ones are observed near of hydrotechnical works. Actually the landslides are present even in some dams of the reservoirs used for irrigation. This phenomenon is risking even some historical objects of national importance such as the Medieval Castles of Kruja, Gjirokastra, Rozafa in Shkodra, and that of Lezha. The activation of the landslide is stimulated from the big activity of the earthquakes in Albania.

Slope stability and landslides has been an object of the geological-engineering studies in Albania. During the last twenty years, the landslides have been investigated using integrated geological, geophysical engineering and geodetic methods.

Control and monitoring study of stability of slopes and landslides that are presented in this lecture has been prepared on the basis of the third chapter of the book "Engineering and Environmental Geophysics", a publication of the Academy of Sciences and the Faculty of Geology and Mining, Tirana, 2005, of the author Alfred Frashëri, (ISBN 99943-763-5-7), on the monograph: 'Slope Stability Evaluation and Investigation and Monitoring landslide using geophysical data " of the authors Bushati, S, Frashëri, A., A., Nishani, P., Silo , V., Pambuku, A., Dema Sh., Komac M., Bavec M., Jemec M., Kumelj Sh., a publication of the Academy of Sciences, Tirana, 2008, (ISBN: 978-99956-10-14-7), as well as Open Lecture "*Investigation and monitoring of the slope stability and huge landslides in Albania using geophysical method, of Prof. Dr.* Frashëri A., Faculty of Geology and Minig, and Faculty of Construction Engineering, Polytechnic University of TiranaUniversiteti Politeknik i Tiranës, 2010..

This lecture has also reflected the new achievements of research and monitoring of slopes and landslides over the past five years, as the problem of occurrence of intense slides across the territory of Albania in the winter of 2010.
The author will consider that his duty is done if this lecture will give its contribution towards the multidisciplinary integrated study of slope stability and landslides invetigation, as well as monitoring the dynamic development of the landslis by application of modern methods and technologies by the specialized Institutions, to avoid human losses and minimize material losses. But above all it is necessary to state legislators and central and local administration should prepare the relevant legislation and require the strict enforcement of laws to remedy the human impact of causing deterioration in the stability of slopes and development of landslides. It is the pressing problem of the day to take the appropriate measures to monitor known landslides to minimize damage and avoid catastrophes.

The lecture will serve the students of engineering faculties, who in their profession related to the landslide's phenomenon.

- Integrated and multidisciplinary study methodic for slope stability evaluation, and landslide investigation - monitoring
- Slope stability evaluation and landslide investigation and monitoring using geophysical data in Albania
- Bibliography

2. INTEGRATED AND MULTIDISCIPLINARY STUDY METHODIC FOR SLOPE STABILITY EVALUATION, LANDSLIDE'S INVESTIGATION, AND MONITORING

2.1. Integrated geological-geophysical-geodetical in-situ investigation for landslide prognosis, study and monitoring in Albania.

Slope stability evaluation and the investigation and monitoring of landslides represent a multidisciplinary investigation, which should be performed by in situ

integrated multidisciplinary geophysical-geological-geodesic-geotechnical-remote sensing and borehole logging technologies :

- Geological Mapping
- Geomorphological Mapping
- Hydrogeological Mapping
- Engineering Geological Mapping
- Remote sensing surveys
- Geophysical Mapping, in-situ investigation and monitoring
  Gravity micro survey
  Magnetic micro survey
  High Frequencies Seismic Tomography and profiling.
  Geoelectric Tomography, electric soundings and profiling, etc.
  Electrical, radiometric, sonic etc. well logging
- Laboratory analysis and determinations
- Geodesic observations.
- Mthematical-physical-geological modeling of the landslide;
- Statistical analysis of the acquired information and to determine the deformation processes through systematic measurements in order to forecast hazardous geodynamic processes.

These methods enable collecting accurate data and sufficient information for implementing constructive projects in order to avoid the risk of the nature related to the land sliding phenomenon (Aliaj Sh. et al. 2010, Anon: 1995, Bogoslovsky V.A. et al. 1977,Camberfort H., 1972, Dziewanski J. et al., 1981, Bushati S. et al. 2008, Frashëri A., 2005, 2010, Konomi N. etj. 1988, Prem V. Sharma, 1997, Telford W.M. et al. 1990,).

Integrated geological-geophysical-engineering studies have a complex character:

a) To study the landslide body structure and soil of the landslide area,
b) Spatial analyse of landslide driven factors, landslide susceptibility model development.
c) Evaluation of in-situ physical-mechanical properties of soils and rocks,
d) In-situ monitoring of landslide phenomena dynamics
e) Determination of the near Earth surface and deep geological-geophysical factors that controlled creation, activation and dynamics of ecosystem's destruction.
f) Evaluation of the anthropogen impact for activation of the slope systems destruction and their dynamics.
g) Slope stability, landlides and downfalls classification in region and country, according to the area geological setting and geological hazard.
h) Presentation of the technical-engineering measures recommendations for avoid or reduction of the negative environmental effects from the land-sliding phenomenon.
i) Prognosing of the slope instability and landslide development in the future,
j) Organization a geophysical, geological, geodetic, Geographic Information Systems (GIS) and other information's database, for landslide sites on the country territory.

Consequently, geophysical-engineering studies with their complex character are able:

1) To study the landslide body structure and soil of the landslide's area,

2) To in-situ evaluate physical-mechanical properties, and mineralogical stydy of soils and rocks, and
3) In-situ monitoring of the landslide phenomena development dynamics.
4) To prognoses slope instability and landslide development possibility in the future,

In-situ intergrated investigations and monitoring is necessary programmed to perform in three phases:

1. Surface integrated geological-geophysical maping, geodesic and remote sensing surveys, and installation of geophysics and geodesic markers.
2. Drilling of shallow boreholes, cross-hole seismic survey, well logging and sampling.
3. Monitoring through periodical geophysical surveys and geodesic observations in boreholes, and remote sensing surveys on the ground surface, and soil and rocks mass movement dynamics.

2.2. Geophysical investigations

In the geophysical methods complex can be included application (Bushati S. et al. 2008, Frashëri A. 2005, 2010, Frashëri A, et al. 1999, 2000):

- Seismic tomography and 2D and 3D shallow refracted and reflected multiple covering survey;
- Recording of the seismic-acoustic activity;
- Setting the accelerometer network in one of the biggest landslides;
- Geoelectrical tomography, vertical electrical sounding and profiling;
- Well-logging in boreholes;
- Magnetic micro survey;
- Gravity micro survey;

Seismic syrveys: The basic method is the seismic tomography and high frequency refraction seismic profiling. The tomography can be combined with refraction seismic profiling of high frequencies at different landslide’s area sectors. The longitudinal and shear waves were recorded through the time intercept method. The hole-hole time-lapse seismic tomography of longitudinal and shear waves can be included in the surveys program. The natural seismic-acoustic activity inside and outside of slipping body is necessary to observe.

According to the surveys' data the velocity of P-waves (Vp) and S- waves (Vs) can be calculated the layer thickness, as well as the physical-mechanical properties must be esstimated for soils and rocks: Poisson ratio, elasticity dynamic modulus, Bulk modulus, rigidity modulus and compression volumetric strength modulus (Bruno F. et al. 1998, Frashëri A. 2005, 2010, Pyrak Nolte et al. 1998, Rykounov L.N. et al. 1983, Williams R.A. et al. 1996).

Puasson Ratio:

$$\nu = \frac{V_p^2 - 2V_s^2}{2\left(V_p^2 - V_s^p\right)}$$

Dynamic Elasticity Modulus:

$$E_1 = \rho \cdot V_p^2 \frac{(1+\nu)\cdot(1-2\nu)}{1-\nu} \cdot \frac{1}{10} \qquad \text{in } \left(\frac{N}{cm^2}\right)$$

$$E_2 = \frac{1}{9.81} \cdot E_1 \qquad \text{in } \left(\frac{KG}{cm^2}\right)$$

where: ρ - Density, in (g/cm3)
V_p, V_s – The longitudinal and shear waves velocity, respectively, in (m/sek)

Static Elasticity Modulus: in cases for $E \geq 2.5 \cdot 10^5 \ \frac{KG}{cm^2}$:

$$E_s = \frac{E_2 - 0.97 \cdot 10^5}{0.83}$$

Bulk Modulus:

$$K = \frac{E_2}{3(1-2\nu)} \cdot 10^5 \qquad \text{në} \left(\frac{KG}{cm^2}\right)$$

Rigidity Modulus,.

$$G = \frac{E_2}{2(1+\nu)} \cdot 10^5 \qquad \text{në} \left(\frac{KG}{cm^2}\right)$$

Volumetric compression strength modulus:

$$\sigma = \rho \cdot \left(V_p^2 - \frac{4}{3} V_s^2\right) \cdot \frac{10^{-6}}{9.81} \cdot 10^5 \qquad \text{në} \left(\frac{KG}{cm^2}\right)$$

Geoelectrical surveys: Electrical soundings can be performed by the Schlumberger array, with spacing up to AB/2 = 500 m, which allowed to reach a survey depth of 120-150 m. Resistivity profiling can be carrying out by multiple Schlumberger arrays with two-five investigation depths, relating to the required depth of investigation for each object. It is necessary evaluating of the anisotropy of geoelectrical section. Geoelectrical time lapse tomography to investigate the landslide area and monitoring of the landslide developing dynamics should be included in the investigation program. Resistivity Realsection of the geoelectric tomography can be performed by multiple spacing gradient arrays, with maximal spacing in dependence of the investigation depth (Dahlin T. et al.. 1997, Li Y. et al. 1992, Loke M.H. et al. 1996, Frashëri A. 2005, 2010, Ogilvy R.D., et al. 2009, Wilkinson J.Ch., et al. 2011,).

According to statistical dependencies can be evaluate the physical-mechanical properties of the soils and rocks, according to their electrical resistivity values.

Elasticity Static Modulus: ex. for diabase:

$$E = \left(38{,}6 \cdot \rho + 4{,}7 \cdot 10^4\right) \cdot 10^5 \ \frac{N}{m^2}$$

Together with the geophysical methods mentioned above, the **micro-magnetic** and **micro-gravity** surveys are part of the integrated investigation of landslide areas. Micro-magnetic mapping present important information for landslide activity prognostic.

h) Well logging:. The gamma-gamma density logging, neutron-gamma logging, electrical logging, acoustic logging and inclinometers can be applied for boreholes documentation. Different well logging methods are able to present high accuracy information about rock lithology, thickness of the layers and physical-mechanical propoerties of the rocks:

Rock's porosity: after electrical resistivity of the rocks, ex. for the sandstones:

$$P = 0.85 * K_p^{-1.7}$$

where: P – porozitety parameter:

$$P = \frac{\rho_{shu}}{\rho_u}$$

Where: ρ_{shu}, ρ_u - eletric specific resistivity of the rock that is 100% satured with water, and water resistivity, respectively.

Rock's permeability:

$$K_{pr} = \frac{1}{P} \cdot \frac{K_p^2}{\left(1 - K_p\right)^2} \cdot \frac{10^3}{K_{uo}^2}$$

where: P- porosity parameteri,

K_{uo}- remanant water saturation coefficient.

Porosity coefficient: according to the sonic logging data, ex. for the sandstones:

$$K_p = 0.175 * \Delta t - 31.6$$

Where: Δt- difference of arrival times of the sonic vavew from source to two receivers in the well logging sonde.

or according to the neutron-gamma well logging data:

$$\log K_p = \log K_{p1} - \frac{I_{n\gamma}^1 - I_{n\gamma}}{I_{n\lambda}^2 - I_{n\gamma}} \cdot \left(\log K_{p1} - \log K_{p2}\right)$$

where: K_{p1}, K_{p2} – coefficients of two marker layers,

$I_{n\gamma}^1, I_{n\gamma}^2$ - neutron-gamma intensivities in two marker layers.

According to these data carried out time-lapse monitoring of physical properties of the slipping body, to evaluate movement slipping mass dynamics.

2.3. Remote sensing technique

Besides the traditional geodetic methods, it is important to apply a new remote sensing technique that uses radar satellite images. Potentially hazardous areas can be detected on the basis of the common interpretation of radar satellite images of high resolutions in complex with the existing geological, geophysical, and geodetical data. The available methods and equipments for estimating vertical ground movement are becoming more and more precise, being able to supply accurate measurements of displacements over the studied region (Boundarchuk V.A. etj. 2010, Bushati S. et al. 2008, Frashëri A. 2010, Geological Survey of Slovenia, 2009, Kin Wah Leung 2003, Kurabashi T., et al 1998, Mialkin B.V. et al. 2004, Zlatopolski A.A. 1992, 1997).

Satellite Radar Interferometry (InSAR) is a technique in which the phase component of the returning radar signals of two or more synthetic aperture radar (SAR) scenes of the same location are processed to allow the detection of ground movements (Fig. 2.1). The need for more accurate results has led to the inevitable technical advances seen over the last few years, including Persistent Scatterer Interferometry (PSI).

PSI is a non-invasive surveying technique used to calculate fine motions of individual ground and structure points over wide-areas covering urban and semi-urban environments. The technique uses an extensive archive of satellite radar data (dating back to 1992) to identify networks of persistently scattering (i.e. radar

reflecting) features such as buildings and bridges, or natural features such as rocky outcrops, against which precise millimeteric motion measurements are calculated retrospectively over the time spanned by the data archive. The unique benefit of PSI is its ability to provide both annual motion rates and multi-year motion histories for individual scattered points.

PSI software analyze the phase responses of the point targets and are able to separate the ground displacement. The levels of measurement precision achieved on the annual displacement rates are of the order +/- 0.1mm/year. With all that satellite observations are not very high periodicity (from 2.5 days to 35 days for existing satellites that have equipment SAR), in some cases satellite methods are able to detect catastrophic phenomenon of active landslides.

Currently used innovative techniques for the analysis of satellite images of the deep structures (Boyarchuk KA, NI Maloushina, Miloserdova LV). The method is based on Geodynamic analysis of geological systems information, and spatial imaging formulation based on the size of the study objects. Results represent the structural model of the territory, which can detailed through the existing geological and geophysical data. In these cases, these data are not mechanically linked with spatial imagery, but they build on and enrich the model, providing new details about the interconnection of internal components. The great advantage of this method is the ability to adapt to tectonic and surface conditions at different, until the landslide's criteria and indicators vary depending on the geological and practical conditions.

Can also be performed computer analysis of space images using standard methods, including software package LESS (Lineament Extraction and Stripe Statistical Analysis-Statistical Analysis of Extraction and deleting features) to compile the structural and tectonic line and blocks scheme of the area (Fig. 2.2). Performed liazing of the spatial image with the existing topographic, geological and geophysical maps for the realization of complex interpretation.

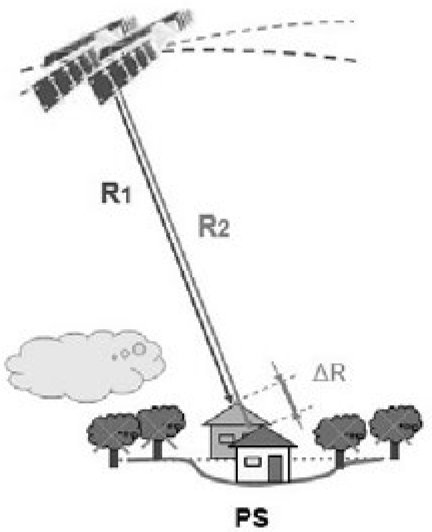


Fig. 2.1. Persistent Scatterer Interferometry technique (PSI) (Geological Survey of Slovenia, 2008-2009)

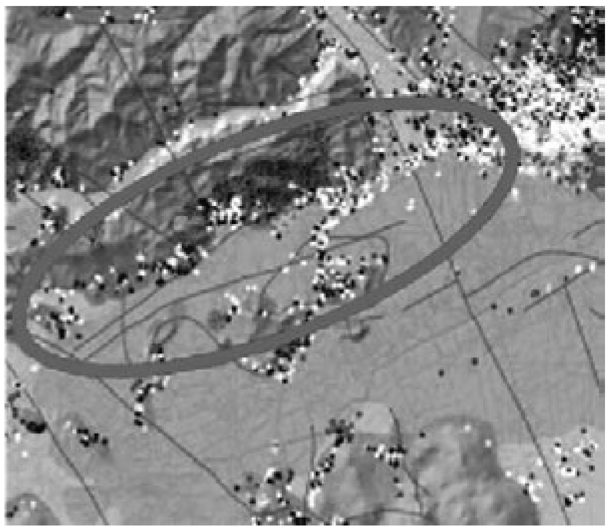


Fig. 2.2. Field validation of displacements Detected with PSINSAR (Geological Survey of Slovenia, 2008-2009)

Based on the results this investigation's phase differ potentially vulnerable slopes and classify their level of the hazard. According to space observation informations, actually can realized the classification of slopes with different potentially hazard levels, which can be accomplished based on:
- Analysis of the deep "photo-portraits of the landscape" areas expected to slide,
- The deep analysis of 3D digitals maps of different indicators
- Developed criteria for the classification of slopes,

Besides the above, studied the internal structure of potentially dangerous slide through:
- a) Detailed examination of the internal structure of potentially dangerous landslides, discovery of the tectonics lines, and glide plane,

- b) Directly survey of the small dislocations (dislocation trend) within the probable slipping bodies.

2.4. Geotechnical methods

Geotechnical landslide's investigations present a wide complex of methods and studies (Bushati S. et al. 2008, Camberfort H. 1972, Dzienvansky J. etj. 1981, Frashëri A. 2005, Galgaro A. et al. 2004, Konomi N. et al. 1982, 1986, Konomi N. 1988, Kurahashi T. et al. 1998,):

- Engineering Geological mapping accompanied with hydrogeological-hydrological observations.
- Samples laboratory determinations of the physic-mechanical properties of soils and rocks of the slipping body and the bedrocks, as well as for further mineralogical and and petrological studies.

- Mathematical modeling, landslide occurrence analysis and production of landslide susceptibility map.

2.4.1. Geological mapping: to map the lithological types of rocks and their structure. He carried out through field surveys, combined with drilling, aerophotogrametric analysis, as well as laboratory determinations. Mapping is performed at different scales up to 1: 2 000, depending on the mapping task. Survey network determined the scale of the mapping. Ex. for the map at the scale 1:10.000 the survey grid should be 20 x 100 m, 10 x 50m for the scale 1: 5.000, etc. Should paid special attention for surveys of the disjunctive tectonics, karst phenomena development, as well as physical-chemical rock's alteration.

2.4.2. Geomorphological mapping: for separate types of the landscape and neotectonics development. In geomorphological maps classified sites according to their suitability for construction and waste collection. Classification can carried out in several classes according to stepness of the landscape surface: $<3^o$; 3^o-4^o; 4^0-5^o; 8^o-12^o; and $>12^o$.

2.4.3. Hydrogeological mapping: by means of which there are data on the water bearing bassins of different types, for aquifer layers and their structure, the water content in the aquifer, the groundwater level and their chemical composition. There are studied ways of supplying water reservoir, the direction of movement of groundwater and assess their dynamics, determining the speed of water flow in the layer.

2.4.4. Engineering geological mapping: which provides data on the geological setting of the area, mainly on the relatively small depth lithology, usually 2 m, 5 m, 10 m, or deeper, as needed, mapping lanslide areas and downfalls, and generally assess the slope's stability, are identified risk areas of soil liquefaction during earthquakes, and determined physico-mechanical properties of soils and rocks. In particular attention is devoted to determining granulometry and compression stregth of soils and rocks, classifying them into several classes.

2.4.5. Laboratory determinations: In not destroy the samples samples determined physico-mechanical properties of rocks and soils, mineralogical - chemical composition and their pertographic peculiarities:

- Granulometric composition
- Plasticity
- Natural moisture
- Volumetric mass and sceleton volumetric mass
- Specific weight
- Porosity coefficient
- Consistency indicator
- Angle of internal friction
- Cohesion
- Compressional Module, Permitted Charge
- Mineralogical determinations, Petrographic study

2.4.6. Borehole drilling: Drilling of boreholes made to obtain rock samples from the bedrocks, for the geophysical well logging, and hydrogeological surveys, as statics and dynamics water's levels, dynamics of the freatic and underground waters, their monitoring.

2.5. Geodetic surveying;

- Topographic detailed mapping and geomorphological surveys,
- Setting of the geodesic markers, GIS levels and coordinates monitoring (Coe J.A. et al. 2000).
- Analysis of the surface deformation based on PSInSAR method in the landslide area.
- Borehole deflection records monitoring.

2.6. Monitoring records

Monitoring of the slope stability and the landslide dynamics should be carry out by a time-lapse complex methods: remote sensing observations and repeatable geophysical integrated surveys on landslide.

Analyze of the time-lapse of the physical-mechanical properties of slipping body and top of the bedrocks, the landslide monitoring represents. The monitoring center will have shallow boreholes down to the bedrocks. The hole-hole time – lapse seismic and geoelectric tomographies, and gamma-gamma density logging can be included in the surveys program. Consequently, slipping body between these boreholes will be object of periodically in-situ determinations of physical-mechanical properties, and mineralogical changes of the glide plane rocks through their influence in the underground waters. The natural seismic-acoustic activity inside and outside of slipping body has been observed for a continuous time of 5 seconds.

2.7. Constructive and environmental evaluations

Based on results of integrated geological- geophysical-remote sensing and geotechnical investigations and evaluations, landslide monitoring, specific impact's effects of Climate Change on nature observations, studies on the flora in the sliding areas, anthropogeneous impact on geoenvironment, and risk assessment, can be prepared and presented the constructive recommendations for avoiding the natural risk, which can be possible. During the phase of planning infrastructural objects, landslide zones could be placed outside the areas planned for construction of infrastructural structures. Method of landslide rehabilitation it is necessary to develop.

3. SLOPE STABILITY EVALUATION AND LANDSLIDE INVESTIGATION AND MONITORING USING GEOPHYSICAL DATA IN ALBANIA

3. Discussion and Analyses

There are analyzed some representative results from the investigation of slipping in Albania, which have been developed in different geological conditions. There are discussed the possibility of using geophysical studies to learn about the slipping phenomena and situation in the condition of the geomorphologic architecture of a mountainous country as Albania. The results of the geophysical data for in-situ evaluation of the physical-mechanical properties of the rocks in the unstable slopes is included in this analyze.

3.1. Landslide at the lakeshores of the hydropower plants.

Hydrotechnical works in Albania are generally constructed in conditions of rugged terrain and in geological formations in which the land sliding phenomena is often present. The land sliding phenomena develops in the basement rocks and the overlaid loose sediments in lakeshores. This phenomenon has been more evidently activated after the construction of hydrotechnical works (Frashëri A. etj 1997, 1998, 2000, Konomi N. et al. 1986). The exploitation period of more than 25 years of such a huge hydrotechnical work has influenced to the physical-mechanical properties at various parts of this landslide.

3.1.1. The Porava Landslide

A study conducted in the Fierza hydropower plant, constructed over the Drini River in Northern Albania, is a clear example of it. This hydropower plant was build in 1974 and has an installed capacity of 500 MW. The lake, created after the construction of the plant, has a water volume of 2.7 billion m^3. The hydropower plant consists of several complex hydrotechnical works. The main one is the dam with stones and a clay core, which has 165 m high and 500 m long. There are observed active landslides in the lakeshores of hydroelectric power plants, which represent a great geological risk at Porava village, about 2.5km from the dam (fig. 3.1). This phenomenon has been more evidently activated when hydrotechnical works started to be used. During the exploitation period of more than 25 years, the huge hydrotechnical works influenced the physical-mechanical properties in the shore area and caused a series of landslides. According to geological data, gathered during the design period, Porava landslide has a slipping mass of about 34 million m^3 (Dhame L. 1974, Frashëri A. et al. 1997, Muço B. 1987, Radovicka P. etj. 1976).

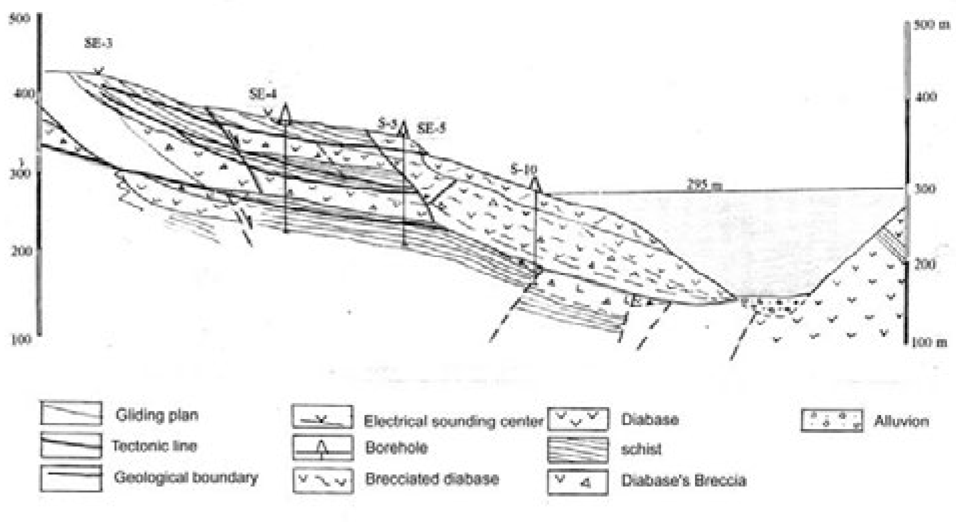
The studies have not only included the geological understanding of the shore's solidity but also the understanding of the landslides. They also include solidity-integrated calculations through the hydraulics patterns. For that, the body fall of the Porava landslide at different speeds (from 5-10 m/sec) was simulated. As calculating parameters were used the ones resulted from geological studies of that time.

Fig. 3.1. Porava Landslide area map, satellite view, and landslide impact on willage houses.

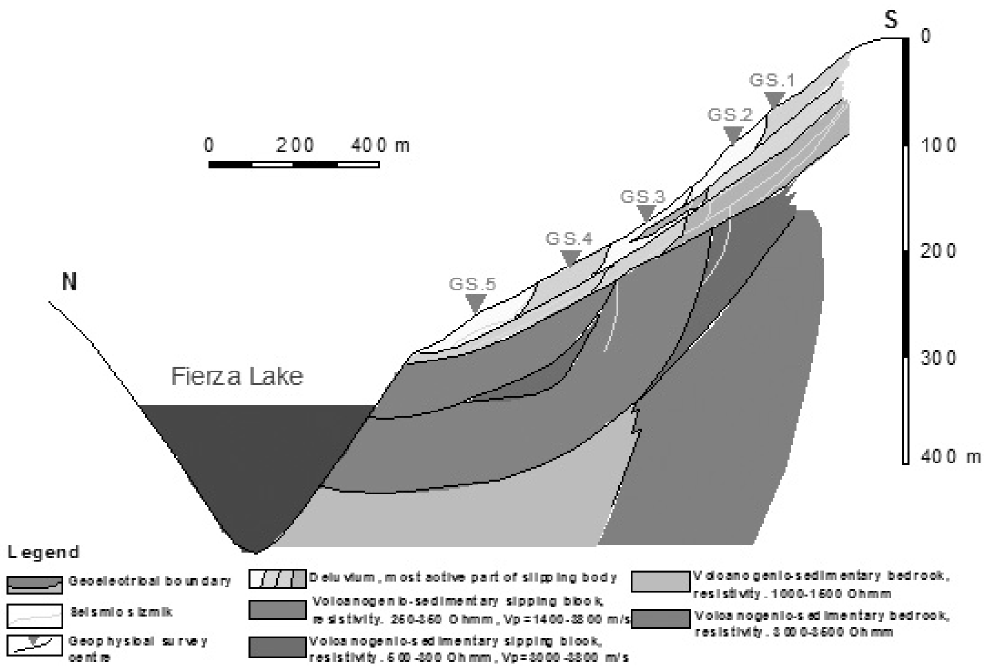
In Fig. 3.2 is presented the detailed geoelectrical - engineering section. This section was compiled based on the date of the vertical electrical soundings. In that can be noticed the presence of the very heterogeneous electrical medium in strike and depth. There are two categories of geoelectrical borders in the profile. These are the primary borders, connected with the separation of the main zones of the slipping body (with that of the deepest plains 140-160 m deep and with that of the most superficial plane 20 m deep). These slipping plains have very different geoelectrical characteristics, because they have different geological properties.

The second category belongs to the secondary geoelectrical borders, which clearly express the changes and the heterogeneity that exists in these two slipping planes and in the environment under them.

First of all, in these geoelectrical markers is expressed the full configuration of the sliding structure in the rocks of the volcanogenic sedimentary section. As a result of the slipping phenomena, these rocks have low, up to medium specific electric resistivity values (200 - 100 Ohmm). While the rocks located under the whole massive slipping body have higher specific electric resistivity values (in the furthest sector of the profile in the lake side 3000 - 3800 Ohmm and 1200 - 1400 Ohm in the sector located near the artificial lake of the Fierza hydropower plant).



a)



b)

Fig. 3.2. Geological (1974)(Dhame L. 1974 (a) and geophysical data (b) (1996) data comparison.

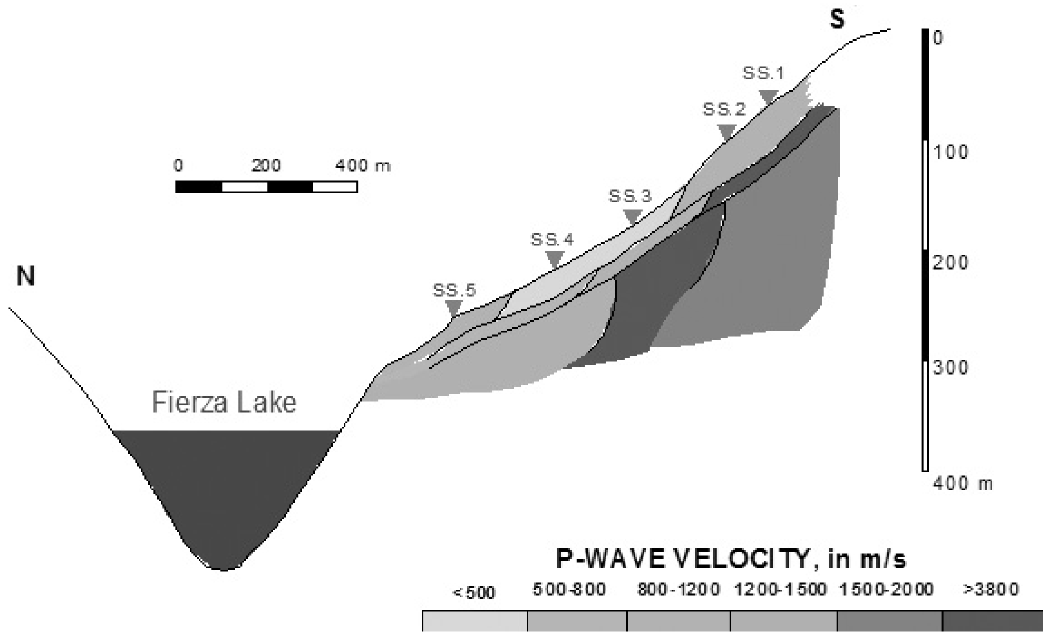


Fig. 3.3. Seismic engineering profile, Porava Landslide (1996).

The most upper part of this slide's body, represented by the deluvial-eluvial deposits, is very active today and has very law specific electric resistivity values (120 - 500 Ohmm). Houses and other objects of the Porava district are constantly damaged by this activity.

The apparent geoelectrical heterogeneity in the strike of the profile, expresses the block kind composition that has in general this slide and it also gives an envision of the development of this slide in time.

In fig. 3.3 is presented the seismic-engineering section in the same profile with the geoelectrical one. In this figure can be distinguished very well the upper part of the slipping body (the zone 25 m deep). In this section are very well distinguished the two seismic parameters (in the speed of the longitudinal and cross waves). The deluvial deposits have been fixed with Vp = 400 - 1200 m/s and Vs = 150 - 450 m/s values, while the eluvial deposits and the volcanic rocks of the most upper part, located over the slipped plane have Vp = 800 - 3880 m/s and Vs = 350 - 800 m/s values. The volcanic deposits located below the first slipping plain have been fixed with Vp = 1400 - 3800 m/s and Vs = 600 - 1500 m/s.

Based on the seismic parameters, the evaluation of the physical - mechanical characteristics of the rocks of this sliding body was carried out in strike and depth. In this seismic section and in the geoelectrical one, can be seen the block kind nature of the upper part of the slipping body and also of the lower part of this body in the basement volcanic rocks.

By studying the natural seismic-acoustic activity, different recordings can be noticed in all the surveying zones. This shows that the sliding activity is different for different parts of the slipping body. The most dynamic zones of this sliding massif are located in places where the micro - movements have maximum intensity values. The Porava village is located in one of these zones. Because of this activity, many houses, and the soil is damaged and slopes have moved about 2 - 4 m within a 2 - 3 years period of time (1994 - 1996)(Photos, fig. 3.1).

In the detailed and integrated geophysical - engineering sections, can be noticed a concordance between the electrical sounding results and the seismic surveying ones, used for studying this slide. Also, in these sections can be determined sliding plains, their nature, situation and the content of the two parts of the slipping body. The most upper part is made of deluvial-eluvial deposits and reaches up to 20 m deep, above the first most dynamic plain of this zone. Under this lays the volcanic rock massif, located over the deeper plane of the Porava landslide (100- 160 m). This plain is determined and separates the block like sliding body from the volcanic rocks, which have not been touched by this sliding activity.)

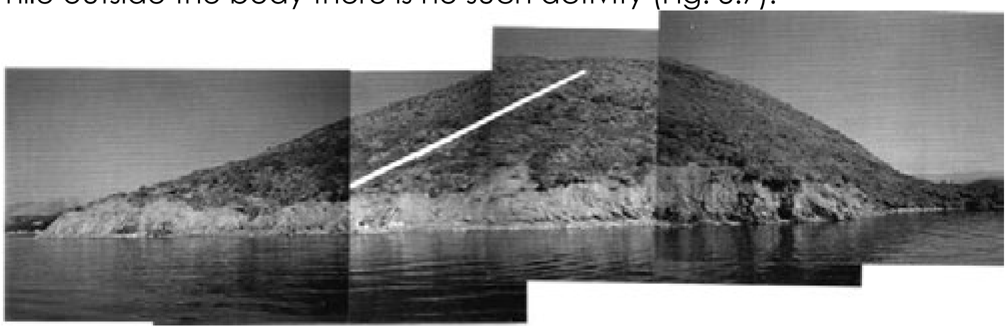
Based on the results of this integrated geophysical-engineering and geotechnical study result:

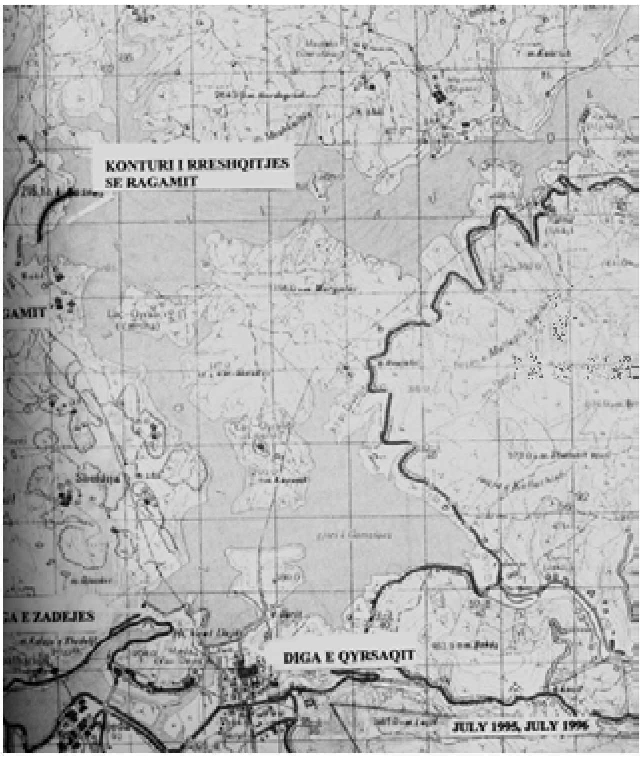
1. There could not happened an immediate fall at any speed of the Porava slipping body.
2. Even in cases of powerful earthquakes, the slipping body mass can not fall as a whole, because it is made of broken up block masses. It can fall parts by parts or in fragments. Natural or inductive earthquakes of normal intensity, which happen often in this region, till now have not caused massive detachments of the slipping body.

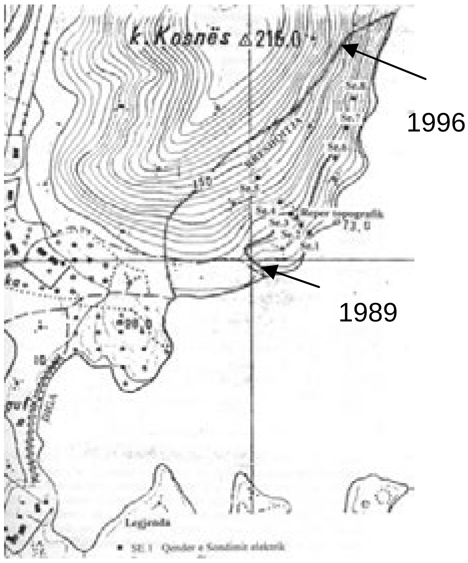
3.1.2. The Ragami Lanslide

The typical landslide was developed at lakeshore of the Vau Dejes Lake of Hydropower Plant in Northwestern Albania (Fig. 3.5). It is developed in the ophiolitic formation represented by serpentinized rocks. The slipping body represents a big mass of serpentinite, which is eolated, destroyed and covered by a thin layer of deluvium. According to the geological survey in 1992, the landslide did not exist. Landslide has been significantly developed during the last ten years (Fig. 2.7). The yearly movements of water level at Vau Dejes Lake caused a big landslide at eolated, weathered and destroyed serpentine rocks. Slipping body increased in the extent and in the volume substantially during this period. The front part of the slipping body is located along the shores of the lake. This part has the shape of a scarp about 2 -3 m high, and represents a destroyed, schistose serpentinite, partly in a form of mylonite (Photo in fig. 3.5) (Frasheri A. et al. 1996, 1989).

In fig. 3.6 –a, b are presented the integrated geophysical - engineering sections of the slipping body. Two main sliding plains separate this body. These plains are broken up. The first plain is at depths of 5 - 7 m, while the second one reaches up to 22 m. The lowest part of the second plain touches the lake, under the water level. In this way, the sliding body has a block like nature. The physical - mechanical properties of the rock massif of the slipping body are lower than those of the basement rocks, not touched by the sliding phenomena. The micro movements in the slipping body are very intensive and have a wide frequency band, while outside the body there is no such activity (Fig. 3.7).







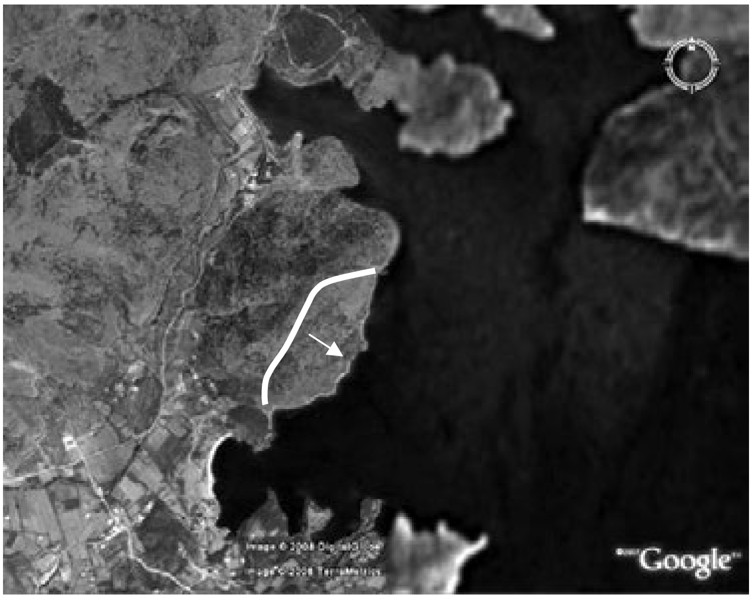
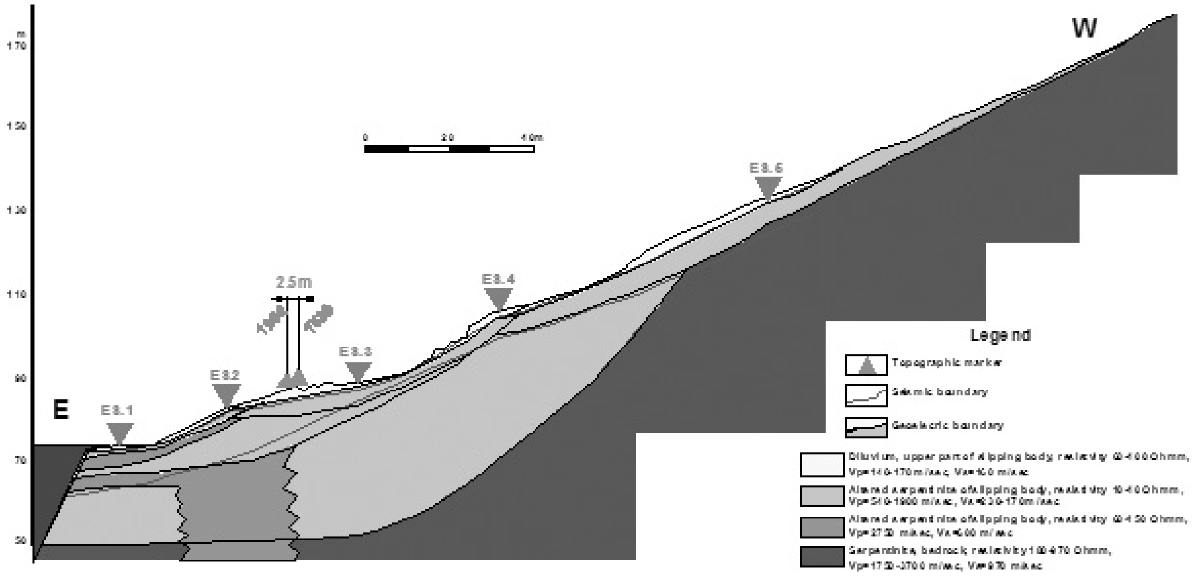
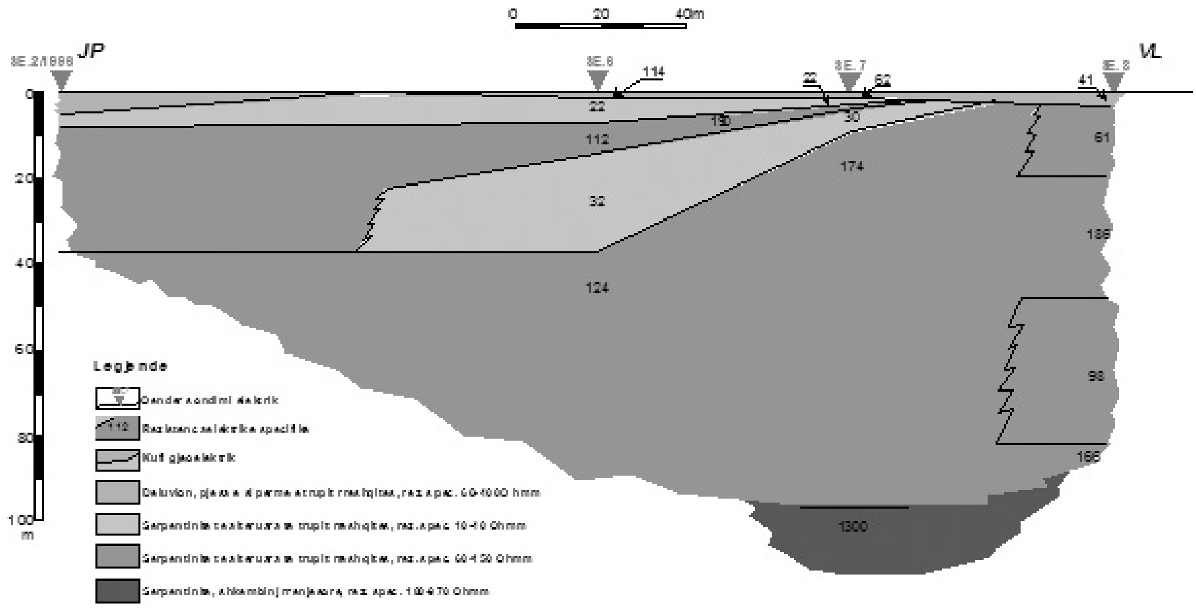


Photo of the Ragami landslide area, andf front of the body, represented by mylonite serpentinites (b)

Fig. 3.5. Topographical sketch of Ragami Landslide area (1989; 1996) Landslide body contours, respectively, and satellite view.



Transversal profile



Longitudinal profile

Fig. 3.6. Engineering integrated geophysical section of the Ragami landslide.

Three failures in different superficial levels can be observed in this landslide:

- The first one 35 - 45 m from the shore, with a horizontal dislocation of about 2 m.
- The second one about 70 - 90 m from the shore, with a vertical jump of about 2 m.
- The third one about 115 - 130 m from the shore. This is the newest level and has the lowest amplitude.

The physical-mechanical properties of the slipping body are lower than those of the basement rocks, not touched by the sliding phenomena.

Physical-mechanical properties of rocks in the area of Ragami Landslide are presented in Tables 2.1 and 2.2.

PHYSICAL PROPERTIES IN LANDSLIDE'S AREA

Tab. 2.1

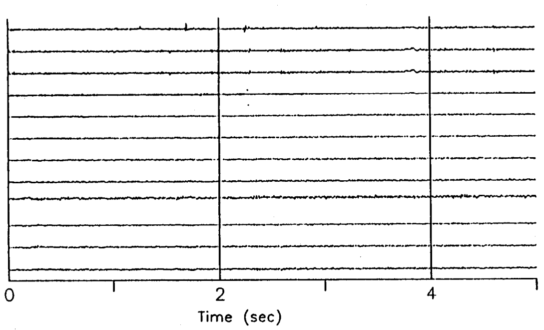
Layer Number	Thick-ness, in meters	Resistivity in Ohmm	Density, in g/cm^3	Wave Velocity, in m/sec		Lithology
				Vp	Vs	
SLIPPING BODY						
1	0.7	76.4	1.34	210	160	Deluvium
2	4.0	29.5	1.61	540	230	Breaking serpentinite
3	6.5	46.5	2.45	3700	680	Water-bearing serpenti-nite,
4	17.4			1500		Breaking serpenti-nite
BED ROCKS						
		485	2.56	3500	1920	Serpentinite

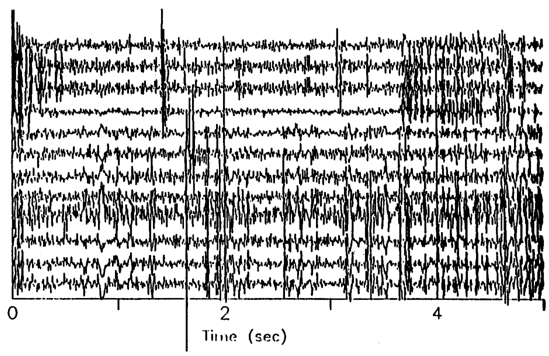
MECHANICAL PROPERTIES IN LANDSLIDE'S AREA

Tab. 2.2

1. Layer Number	Poisson's Ratio	Dynamic Modulus of Elasticity, E_d^s in *10^5 kg/cm^2	Rigidity Modulus G, in *10^5 kg/cm^2	Volume Compre-ssion, σ, in *10^5 kg/cm^2	**Rock state**
SLIPPING BODY					
1	0.35	0.00370	0.00140	0.00420	soft rocks
2	0.39	0.02413	0.00868	0.03630	Destroyed, shattered rocks
3	0.48	0.56586	0.19167	3.26503	Cleavages and fissured rocks
4		0.26325	0.09608		Destroyed, shattered rocks
BED ROCKS					
	0.29	2.46271	0.96199	1.91408	Compact rocks

As documented in Tables 2.1 and 2.2, four layers with different physical-mechanical properties create the slipping body. First layer represents the deluvial cover. Layers 2 and 4 are represented by destroyed-shattered serpentinite. The third layer in between is characterized by low electrical resistivity and low shear waves velocity. It corresponds to the water saturated cleavages and fissures in the serpentinite.





Outside of slipping body Inside of slipping body

Fig. 3.7. Natural seismic-acoustic activity in the Ragami landslide area

After the analyze of geophysical investigations in Ragami landslide, have been concluded:

1. Thick and high volume slipping bodies represent the Ragami active landslide in the shore area of the Vau Dejes Lake.
2. The extent of the landslide and the position of sliding plains were precisely fixed using the integrated geophysical survey.
3. The block-like character of the sliding bodies brings to the conclusion that the block of these bodies can not fall down immediately in any kind of velocity.

3.2. Landslide in the Oligocene flysch formation.

There are instable mountain and hill slopes, slipping of rocks masses, sometime of great sizes and catastrophic results. In some cases even villages or parts of villages were destructed, as Guri Zi in Elbasani region, Moglica in Devolli River region, Gjyras in Maliqi region etc., and without mentioning the blockage of auto-roads and railways.

3.2.1. The Banja Landslide

This slide was created when the derivation tunnel of the Banja hydropower plant was dug. It was developed during drilling in the flysch formations of Paleogene (Fig. 3.8). The high content of thick sandstone layers, dipping according to the relief, is very characteristic for the flych section. This landslide completely ruined the derivation tunnel built till that time.

In fig. 3.9 is given the integrated geophysical - engineering section along the Banja slipping body. The maximum depth of the strike of the sliding mass is 22 m (in the center of the profile). The geoelectrical characteristics of the slipping body are very distinguishable from those of the flysch formation located outside the slide. The same thing is for the spreading velocity of seismic waves. The slipping body is very heterogeneous and is made of different blocks.

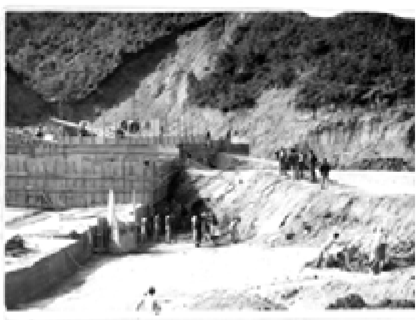
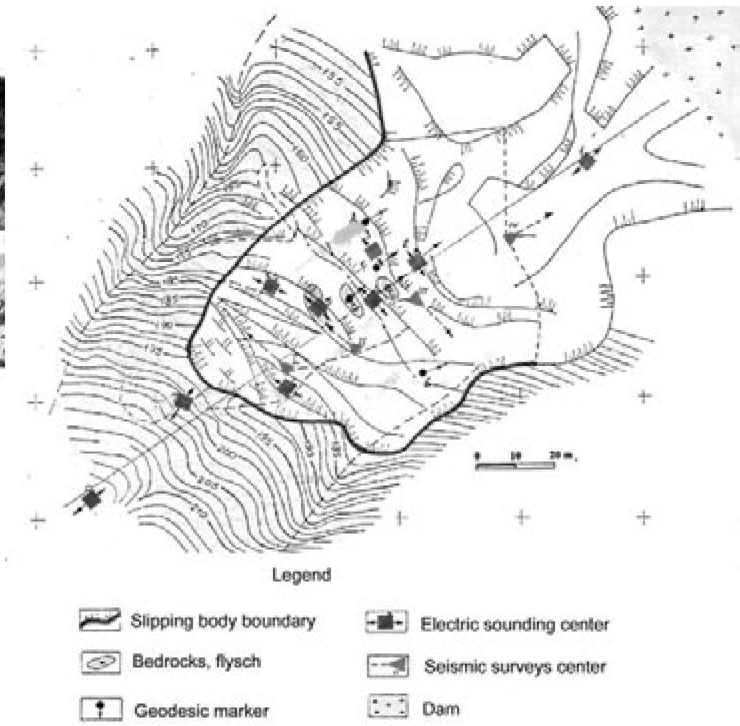


Fig. 3.8. Banja Landslide area,July 1978



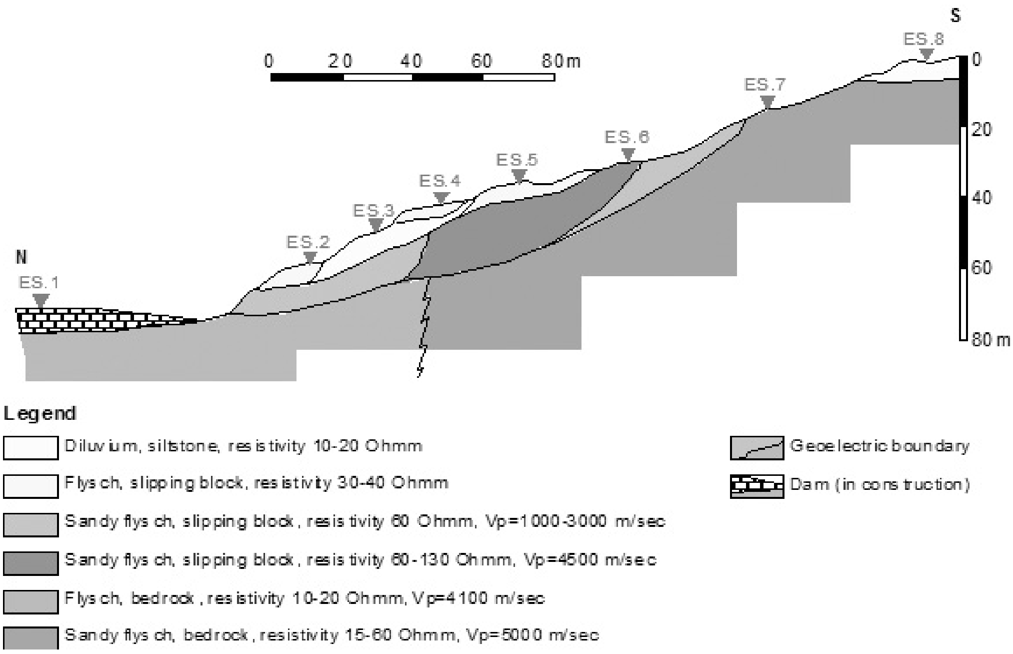


Fig. 3.9. Geophysical section, Banja landslide

This slide was characterized by a very intensive dynamic of the movement of the sliding body mass. For about one month, a sliding mass of 17 000 m^3 was displaced about 5 - 7 m, according to geodesic markers. This dynamic is also expressed in the natural sismoacustic activity. Inside the sliding body predominate higher frequencies than outside it (Fig. 3.10). The micro - movements have an amplitude many times higher.

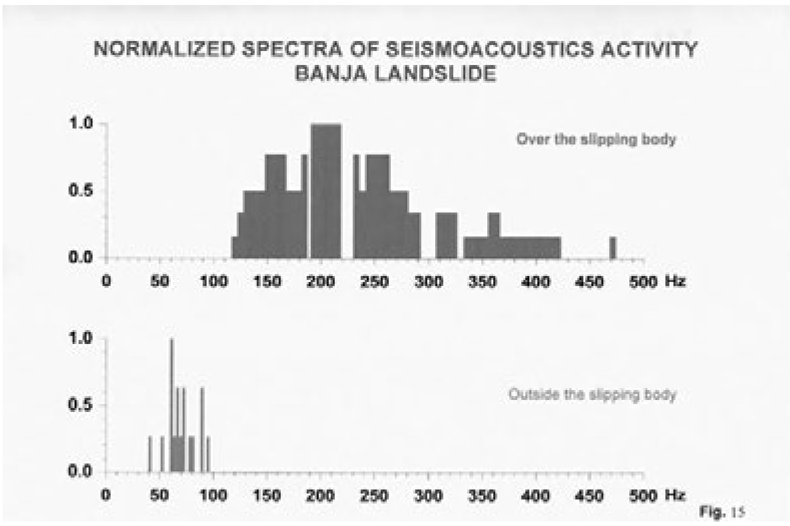


Fig. 2.10. Normalized spectra of seismoacoustic activity, Banja Landslide

3.3. Landslide in the Neogene's molasses formations.

Landslides in the Neogene's molasses are located in several Albanian zones, with different sliding body mass.

Durresi landslide

Durrësi city area is characterized by a presence of neogene molasses formation (Fig. 3.11) (Frashëri A. 1987, Hyseni A., et al, 1976, 1986, Leci V. et al. 1986): sandstone-clay Tortonian deposits, clay, sandstone interbeds and lens, and gypsum debris and blocks Messinian deposits, and silty clay of. Pliocene Helmesi Suite (N_2^H). Durrës structure is asymmetric top part of the big anticline. Western anticline limb has a dipping about 20-30°. Eastern flank is tectonically abrupt and has a dipping 45-55°. Top Durresi anticline is located about 1600 m at the west of the coastal line.

Part of Durresi city is located over the Neogene's molasses hills (Photo 4.6). The Pliocene clay slope at southern part of the Durresi hills is unstable. There the big landslide activity is observed. Over this slope have been constructed many buildings. Actually, in several buildings have observed wide wall craks (Fig. 3.12)

Fig. 3.11. Subsidence of the villa walls, caused by landslide

Photo 3.12. Cracks in the villa walls and transversaly of the road

3.4. Downfalls in the weathered rocks

Kruja Castle

The Castle of Kruja is the symbol of the culture and Albanian history. This castle is related with the most glorious epoch of the Albanian National Hero Skanderbeg (Fig. 3.13) (Frashëri A. et al. 1997).

Fig. 3.13. Downfalls in the Kruja Hill.

Many excavations have been conducted up to present, aiming at bringing out the interior part of the Castle and the clock tower. The surrounding walls have been completed with a museum structure as the Museum of the National Hero, where every visitor gets acquainted with one of the most remarkable moments of the Albanian history. In 1995, the Castle, which was considered relatively safe, was "shaken up" under the Gjergj Kastrioti Skenderbeg Museum. The downfall occurred after a period of heavy rainfall, characterized by heavy showers and a rapid decrease of temperature. The overnight downfall of the large detached masses of about hundreds of cubic meters was unexpected. Now the ground has started to deteriorate and at the sides of the castle, in some places is developing a process of collapse. This is a well known phenomena for this Castle. The deterioration has also continued during 1996-1997 though the detached rocks have been smaller in size.

Geophysical surveys have been carried out for ground investigation. The results of the surveys are presented on the geoelectrical-geotechnical section (Fig.3.14).

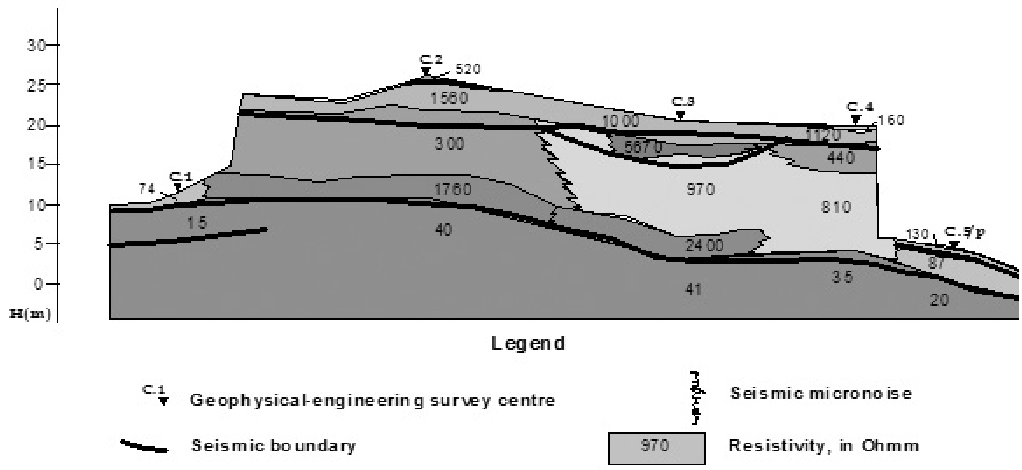


Fig. 3.14. Physical Engineering Section, Kruja Kastel Area.

It can be seen on the section that the rock massive, where the Castle was constructed, is composed of breccia-conglomerate formation. The breccia-conglomerate formation onlaped on the Oligocenic flysch section. The upper part of the flysch section around the Castle is covered by deluvium, 1÷4 m thick. Under the deluvium lays the weathered layer. The breccia-conglomerate massive, where the castle was constructed, consists in 3-4 main layers, which, in extension have different thickness and are heterogeneous. The layer that attracts the attention more is the third geoelectrical layer, which is located at a depth of 3-24 m. Its resistivity varies between 300-900 Ohmm, which is significantly less than those lying over and under that. This layer, generally is characterized also by smaller velocities of longitudinal and transversal seismic waves, which vary between V_{pl} = 500-1800 m/sec and Vs_1 = 400-830 m/sec, meanwhile the layers lying under it have a velocity of the range 2300-3100 m/sec and 870-1050 m/sec respectively. The dynamic module of elasticity of the first seismic layer varies between the limits 390-1400 kg/cm^2, which apparently has a very low value. The statistical analysis of the samples of the volumetric mass resulted in a large distribution of this property. The minimum values vary from 2,12 g/cm^3 to a maximum of 2,45 g/cm^3. These indexes underline the fact that in the surveyed centers we are in the presence of a breccia-conglomerate layer heavily destroyed, containing a large quantity of saturated clay, though in a very weak state.

The observation of the natural seismic micro noises has shown that the breccia conglomerate rock massive has a noise level 2-8 folds higher than in the flysch profile touching along side this massive. This shows that the systematic destruction of the massive is in a continuous process. Inside the rock massive, the seismic micro noises increase towards its outskirts.

2.3. Conclusions

Based on the above analyses can be reached the following conclusions:

1. Geophysical-engineering studies have a triple character: a) to study the soil of the landslide area, b) evaluation of in-situ physical-mechanical properties of soils and rocks and c) in-situ monitoring of landslide phenomena.

2. In the profiles, where integrated geophysical surveys have been conducted, were fixed the bodies of the studied landslides. In these profiles were also clearly fixed the gliding plains. In general, even though the geological conditions in which these slides have been developed are different, the plains have regular configuration, with maximum deepness in the center of the profile.

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THE CLIMATE CHANGE IN ALBANIA, ITS IMPACT ON HYDROGRAPHIC SYSTEM AND ADRIATIC COASTLINE

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Abstract

The general cascade impact of the climate change on Albanian Adriatic Littoral: decreasing country water resources, influence on the hydrographic regime of Adriatic Sea and on ecosystems are presented in the paper. The study is based on the results of inversion of 6 thermologs data for the ground surface temperature history in Albania, and climate change according to the multi annual meteorological data from different regions of Albania. The wells and the meteorological stations are located in Sedimentary Basin of Albania, at the field region in the west of Central Albania and in the ophiolitic belt in the mountainous region of the northeast Albania.

Based on inversion data at coastal plane western region of Albania, GST history presents a gradual cooling before a middle of the 19th century, followed by 0.6 K warming. Climate warming of 0.6 K in the 20th century is observed also in mountainous northwestern Albania. This warming mainly after the second half of the 20th century is presented also by meteorological data: temperature, rainfall, and wind regimes.

There are estimated continental water flow, created by atmospheric rainfalls. Impact on processes of the forming and circulation of the Adriatic Sea water mass has been analyzed by particularly attention, for wet and dry years are analyzed. Estimation of run-off discharges is carried out for two categories of river basins: first, for river systems, where run-off discharge is computed as a function of the altitude of water level river section. Second, for the water system of Scutary Lake-Drini River-Buna River, which is very complicated and is the single in Mediterranean Hydrography.

The warming impact on country climate, and ecosystems of Albania, thermal stress in the wetlands, lagoons and lakes have presented in the paper. Impact it is observed first of all on the biodiversity.

Keywords: Ground Surface Temperature, Climate Changes, Hydrology, Hydrographic System, Adriatic Sea, Environmental Impact.

1. Introduction

Processes of the forming and circulation of the Adriatic Sea water mass, as is well known, presents a discussible phenomenon of the Mediterranean oceanographic dynamics. One of the main factors, which have determined these processes, is water discharge from the Albanian Hydrographic System into Adriatic Sea. Analyze of the factors that conditioned water discharge and their impact on Adriatic Sea Hydrology are presented in the paper.

Climate, geomorphology, lithology and geographical situation of the Albanian Hydrographic Network Catchment, are caused their impact on the water discharge from Albania into Adriatic Sea. Its impact has been observed on some directions:

- Country climate change,
- Water systems and water resources changes. Impact of inland water resources changes on the hydrographic regime of the Adriatic Sea.
- Mechanism of the forming and circulation of the South Adriatic Sea water.

In the first part of the paper is presented detailed analyzes of the climate change in Albania. Albania lies in a subtropical zone. It is a Mediterranean country. Winter is relatively short and mild, humid near the seaside areas. Summer lasts very long and it is hot and dry. To the east, in the mountain areas, the climate is Mediterranean mountainous. The climate in Albania varies from a region to the other, according to the location compared with the seaside, to the seasons, years, and centuries. The ground

temperatures are conditioned by geographical position of the area, area's geology, and ground lithology, dynamics of the underground waters, meteorological conditions, and season. The climate change studies, are based on geothermal inversion results and meteorological observation data.. There is analyzed the ground surface history (GSH) and paleoclimate change according to the temperature measurements in the different wells in Albania. Climate changes during the last half of the XX century has been analyzed also based on the meteorological data.

There are estimated continental water flow, created by atmospheric rainfalls and its impact on processes of the forming and circulation of the Adriatic Sea water mass has been analyzed.

According to the complicated nature of the Albanian Hydrographic System, in the second part of the paper, is presented the Albanian Adriatic Littoral hydrology, and geological setting. In the last part of the paper the observed integrated factors of the coastline evolution are analyzed.

2. Material and methods

Climate change are analyzed in two directions: firstly by temperature record in the deep wells and shallow boreholes, and secondly by the meteorological observations data. The ground surface temperature reconstruction for long period, about 5 centuries, has been performed by estimation of the ground surface temperature changes at the past, according to the present-day distribution of the temperature at the depth, recorded in the borehole. The study of geothermal field of Albania has been carried out based on the temperature logging in the wells and boreholes (Çermak, V. et al 1996, Dimitriev V. I. et al. 1997, Frashëri, A. and Čermak, V. et al. 1995, 1994, 2004,). Six thermoplots were used for inversion of the ground surface temperature history, which are located at the plain region in the west of Central Albania, and in the mountainous region of the northeast of the Albania.

Air and ground temperatures, total annual rainfall quantity, wind speed and wetness, which are analyzed by records in Meteorological Stations. These stations are located in different plane regions (Shkodra, Tirana, Kuçova and Fier) and in mountainous region of Albania (Kukes), where the investigated wells are situated (Albanian Climate, 1978, Boriçi, M. and Demiraj E. 1990, Gjoka, L. 1990, Mici, A. et al 1975, the data for 1985-2007 after Mustaqi V.).

Water potential of the Albanian Rivers System have been evaluated by a specific way, because this System is very complicated (Pano N. 1974, 1984, 1998, 2008). This network has a surface of 43 305 km^2, where 28 500 km^2 is inside the Albanian state territory, and water of the Albanian river system discharge into Adriatic and Ionian Sea. Albanian River System represents in general a mountainous hydrographic network, with an average altitude 785 m above the sea level. Part of Albanian Hydrographic Network are lake system, Prespa-Ohri, and Scutary with a surface from 270-365 km^2. A karstic phenomenon is very intensive in the limestone formation, which is extended in great surface of the country.

Water potential evaluation of the Albanian River Basin based on the multi annual archival data of the Albanian Hydrometeorological Institute of the Academy of Sciences. The monitoring network has more than 22 meteorological and hydrometric stations, during the observed period 20-100 years.

The methodology of the estimation of the water potential, have calculated the annual run-off discharge of the Albanian River System according to the corresponded types of the water supply, structure of the annual discharge distribution, and hydrogeographical types of the river catchment. Estimation of run-off discharge (Qi) are performed for two categories of river basins, with different hydrographical and hydraulical natural conditions:

a). Water system: Scutary Lake-Drini River-Buna River), where the run-off discharge Q_i is computed by $Q_i= F(H_i,Q_l)$, where Q_l represent the discharge of the lateral source..

b). Drini, Mati, Ishmi, Semani , Vjosa River systems, etc), where the run-off discharge Q_i is computed by Q_i-$f(H_i)$, where H_i- level in the river $Q_i=f(H_i)$, where H_i is altitude of the water level river (i) section.

All modeling and calculations have been performed for the model of dry and wet characteristic years, to analyze the climate impact on Albanian Hydrographic System.

Processes of the forming and circulation of the Adriatic Sea water mass have analyzed based on hydrographic data and Results of Albanian Marine Expeditions —Saranda 1963”, —Patos 1964” for the wet years (Pano N. 1974), and Italian-Albanian Expeditions —Italica I and II, 2000 and 2001” for dry years.

Integrated geological-geophysical: onshore surveys of the Albanian littoral areas have begun since 1958. Offshore geological-geophysical surveys on the Albanian Adriatic shoal shelf have started from 1976 (Frashëri A. 1987, 1994, Frashëri et al. 1991, Geological Map of Albania 1983, Leci V. et al. 1986, Papa A. 1985).

3. Results and discussion

3.1. Climate change

The ground surface temperature reconstruction of the thermoplots of Kolonja-10 and Arza-31 deep wells, which are located at coastal plane region of western Albania, are shown in fig. 1. As it is seen in this figure, the GST history yielded by tighter inversion of Ko-10, presents a gradual cooling of 0.6 K, before a middle of the 19th century. Later followed by 0.6 K warming, with a gradient 5.4 mK/years, that seems quite reasonable and is consistent with generally accepted ideas about the climate of the last 2-3 centuries. On the contrary, the paleothermal history, obtained from Arza-31 well, presents a monotone warming of 1,7 K, by a gradient 5.7 mK/year, during the 17th and 19th centuries. This trend of the warming has only explanation caused by a deforestation of the area and presence of the paleo-swamp.

Fig. 2 shows a GST history of Vl-1127, Gurth-595, Krasta-1 and Ragam-168 boreholes, which are located in the mountainous regions of Northeast Albania. Some changes are observed in these regions as to the cooling of 0.2 K during the 19th century. Later, the warming trend of 0.6 K during the 20th century, by a gradient 6.7 mK/year. Warming gradient increasing at mountainous regions, in comparison with coastal areas, is caused by intensive deforestation during the last half of 20th century.

Climate changes in Albania are observed also by the hydrometeorological studies. Fig. 3 presents graphics of yearly average temperature of the air in Tirana and Shkodra Meteorological Stations, for the period from 1931 to 2000. As well known, Tirana is located in Central Albania. In general, the end of first observes half 20th century, a warming of climate, about 1^{o}C. Thirty quarter of 20th century is characterized by a cooling of 0.6^{o}C, and later, up to present a warming of 1.2^{o}C. The same climate changes are observed also at Shkodra City, in northwestern plane area of Albania.

The cross correlation coefficient is C_c = 0.78 between variation curves of the average annual temperatures of both of these stations. Warming trend of maximum 1.2^{o}C, in particular after seventy years, is observed in all Albanian territory (Fig. 4).

There are good cross correlation between variation curves of the average annual temperatures of Shkodra, Tirana and Kukesi, respectively C_c = 0.78 and 0.79. Weak cross correlation C_c = 0.58-0.68 is observed between temperature variation of the Kuçova area and other northern regions.

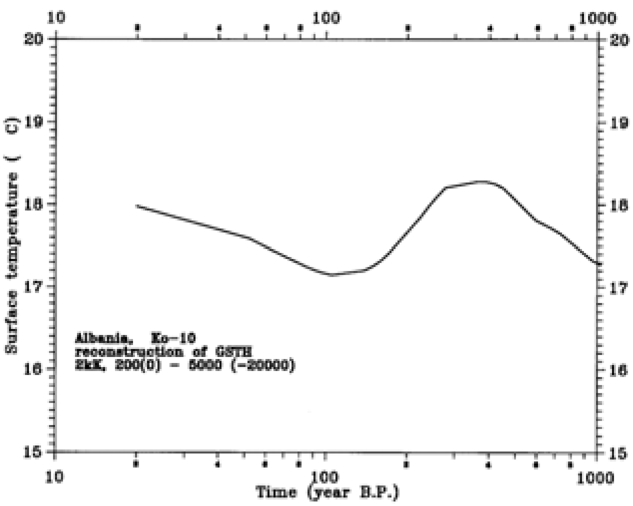


Figure 1. Ground surface temperature history according to thermoplot of Ko-10 and Arza-31 wells (According to the Šafanda, J. calculations).

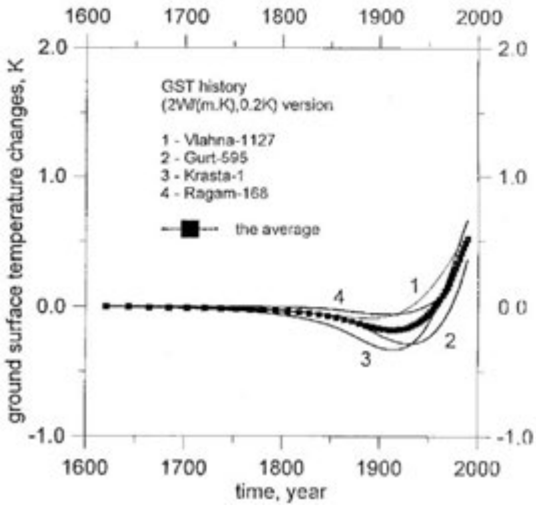


Figure. 2. Ground surface temperature history according to thermoplot of Vl.-1127, Gurth-595, Krasta-1 and Ragam-168 boreholes (According to the Čermak, V. and Safanda, J. calculations).

This phenomenon presents the influence of the local character of the climate changes of Kuçova area. Warming of the soil is more intensive than air warming (Fig. 5).

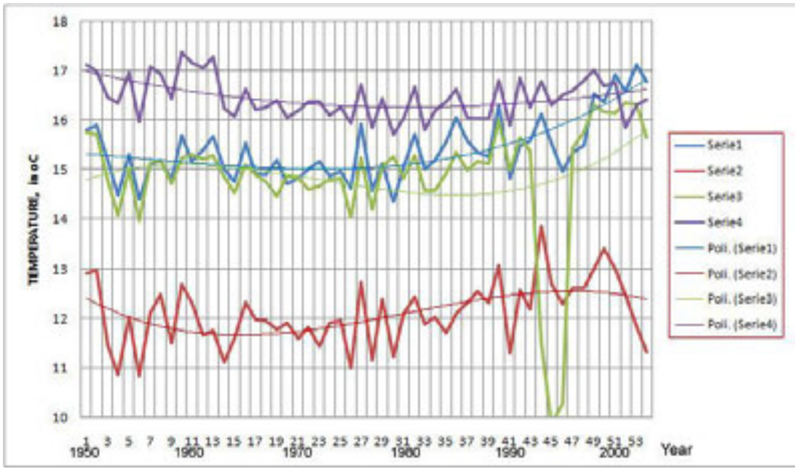


Figure 3. Air Average Annual Temperature Variation at Tirana and Shkodra Meteorological Stations (Period 1931-2004). 1- Tirana; 2- Kukesi; 3- Shkodra; 4- Vlora

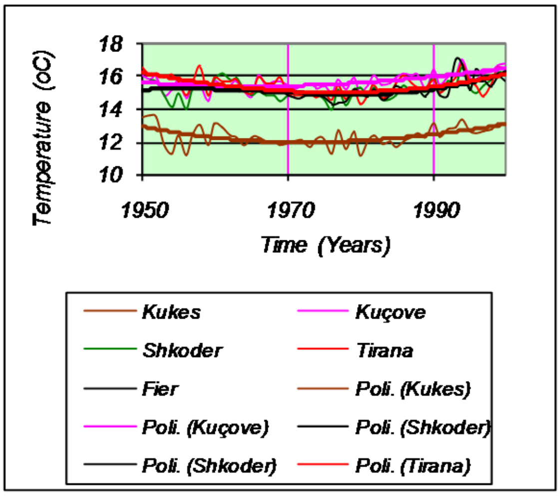


Figure 4. Cross-correlation of the Air Average Annual Temperature variations at Shkodra, Kukes, Tirana, Kuçova and Fier Meteorological Stations (Period 1950-2000).

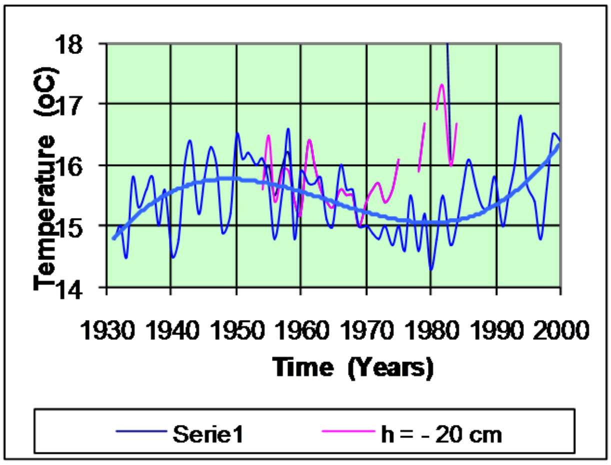
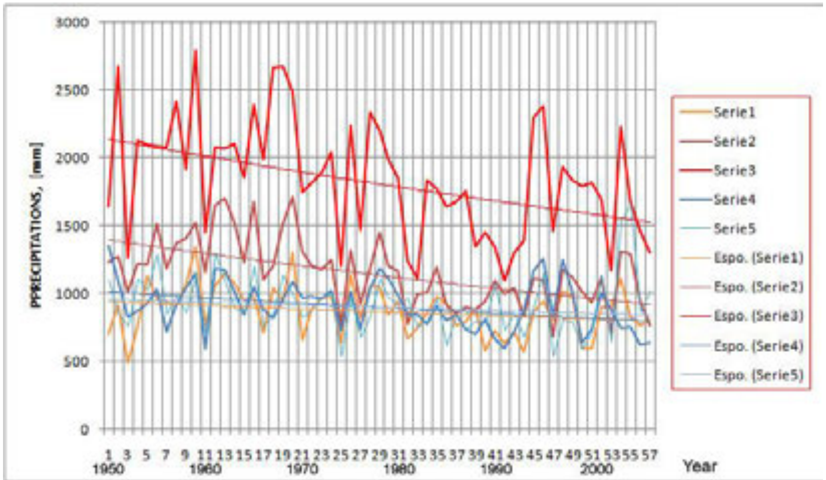


Figure 5. Air and Ground Average Annual Temperature Variation at Tirana Meteorological Station.

The meteorological data shows that the warming trend is not a monotone one. In short intervals are observed cooling and warming (Fig. 3, 4, 5). The meteorological studies have verified warming of the climate during the last quarter of the XXth century, too. It has been consisted that: —Around the 1980's a warming trend is observed" (Boriçi M., Demiraj E. 1990, Demiraj E. et al 1996).

The warming period in Albania is accompanied with changes of the rainfall regime., wind speed and wetness. There are observed a decreasing of the total year rainfall quantity, for about 200-400 mm. (Fig. 6, 7,8).



1- Kukës; 2- Tirana; 3- Shkodra; 4- Erseka; 5- Vlora

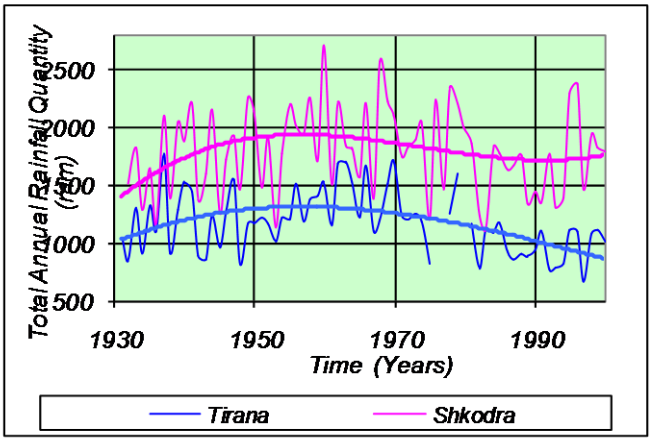


Figure 6. Total year rainfall quantity of the Tirana and Shkodra Meteorological Station (Period 1930-2007).

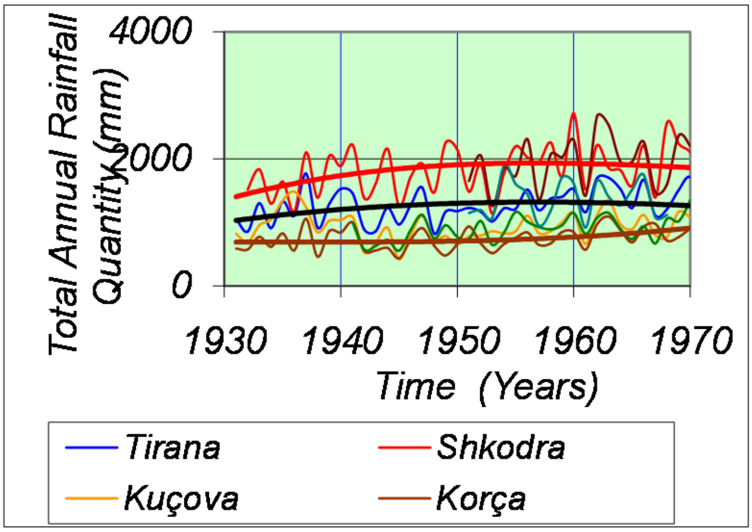


Figure 7. Cross correlation of the Total Year Rainfall Quantity of the Tirana, Shkodra, Kuçova, Korça, Kukesi, Gjirokaster, Vlora Meteorological Station (Period 1930-1970).

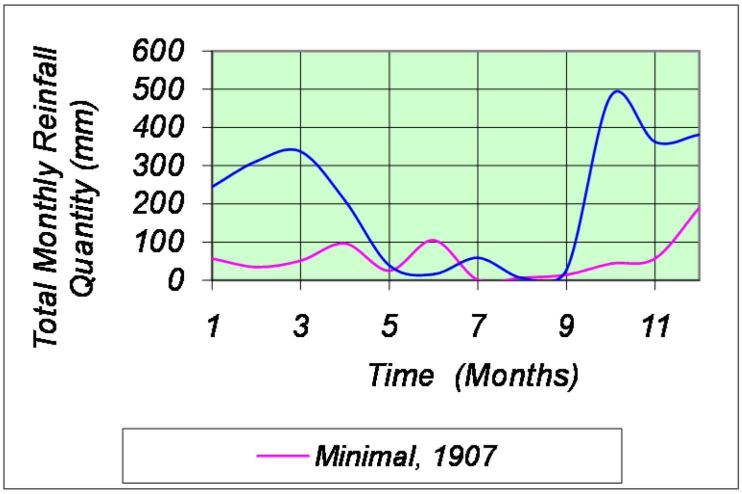


Figure 8. Total Year Rainfall Quantity in the most dry and wet year, respectively, of the Shkodra Meteorological Station (respectively 1907 and 1960 years).

In the dependence of the geographical location of the areas changes the cross correlation of the rainfall quantity: Tirana area with Shkodra area C_c=0.62, with Korça C_c=0.81, Kuçova C_c=0.66, Kukesi C_c=0.88, Gjirokaster C_c=0.88, Vlora C_c=0.53, during the period of 1930-1970. Fig. 8 is presented the difference of the total year rainfall quantity in the most dry and wet years, respectively 1907 and 1960. The warming have accompanied with decreasing of the wind speed about 1.5 m/sec and 5% increasing of the wetness, during the period of 1950-1994 (Fig. 9).

This warming is part of the global Earth warming during the second half of XX century. Its impact has been observed also on water systems and water resources. Inland water resources change has its impact on the hydrographic regime of the Adriatic Sea, and particularly in the Albanian Adriatic Littoral (Frashëri A. & Pano N. 2003). Ecosystems, and biodiversity, in the particularly in the water's flora and fauna. Temperature augmenting has caused increasing of the evaporation in the water systems. Consequently in the river system, reservoirs, wetlands, lakes and lagoon system has been observed thermal stress. In very beautiful ecosystems of Albanian lagoon thermal stress has its impact, first of all on the biodiversity. This stress is extended also in the shallow coastal waters; consequently there are observed diminution of the fish quantity.

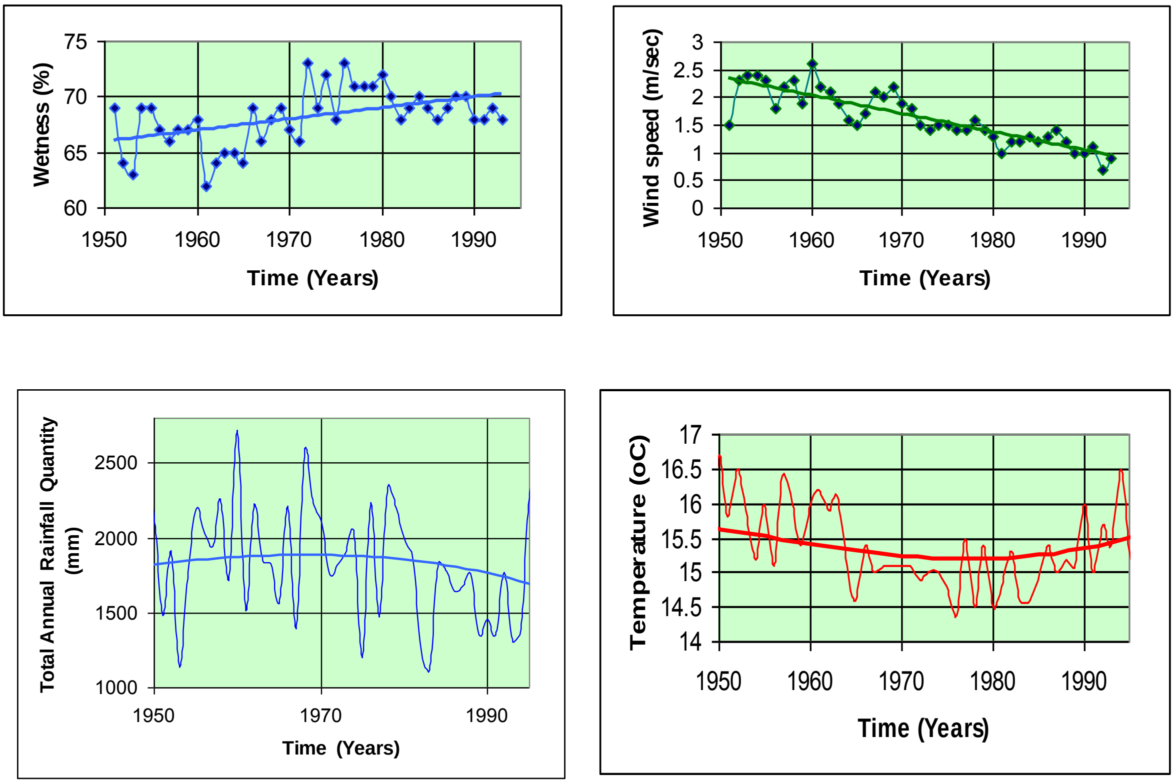


Figure 9. Air Average Annual Temperature, Total Year Rainfall Quantity, Wind Speed and Wetnees Variations, at Shkodra Meteorological Stations (Period 1950-1994).

3.2. Discussion about the climate change impact on the Albanian Adriatic Littoral

The Albanian coastal area lies from Velipoja to Vlora bays. Adriatic coastline is lies over the Neogene Peri-Adriatic Depression, covered by Quaternary deposits. Flattened accumulative coast is general characteristic of this coastline. There are also some hilly marine caps with cliffed coast. The caps are located in the sectors where the Neogene structure of the Peri-Adriatic Depression are abrupt by coastline and continues in the Adriatic Sea, old river deltas or mouths and submarine coastal bar. In fig. 10, 11, 12, and 13 are presented the geomophological evaluation and hydrographic regime of the different characteristics zones of Albanian Adriatic Littoral (Pano N. et al. 1974, 2003, 2004, 2006, 2008, Simeoni U. et al. 1999, Shuitsky Yu. D. et al. 1999).

1) Mouth of Buna River at the north to Rodoni Cap coastline. This unit has a length about 60 km and consists for almost 90% of beaches fed by fluvial imputes. The remaining 10% is clifts. Four rivers outflow within this area: from north to south Buna, Drini, Mati and Ishmi rivers (Pano N. 1998).

2) Rodoni Cap, Durrësi Bay up to Shkumbin River mouth coastline. Cape Pallës, Cape Selitës, Lalëzi Bay, Durrësi Bay and Shkumbini River mouth are main sectors of this littoral area. Lalëzi Bay has a length of coastal line of 32 km, and 65% consists of sandy beaches fed by the sediment load of Erzeni River. The remaining 35% consists of rocky cliffs. Durrësi Bay has a length of 35 km from Pallës Cap to the Selitës Cap. Main part of the bay littoral, about the 54% of their length, by sandy beaches is presented. Frequently, with dune ridges, vegetate by pine trees, there are extended.

3) Shkumbin-Seman-Vjosa rivers mouths up to Zvërneci hills coastline, is located in southern part of Central Albania, and have 40 km length. It expands in the western part of Ardenica and Divjaka hills. Karavasta Bay and Karavasta Lagoon are also part of this littoral area. From the geological viewpoint, this territory represents a new soil, constituted at the end of Pliocene and during Quaternary. The coastline in this region has a very intensive dynamics.

4) Vlora *Bay,* is represented southeastern edge of Otranto Strait. The *Upper* Cretaceous- Triassic limestone mountains are encircled southwestern and southeastern shores of the bay. In the north, the mountain chain is continued with Neogene's deposits hills.

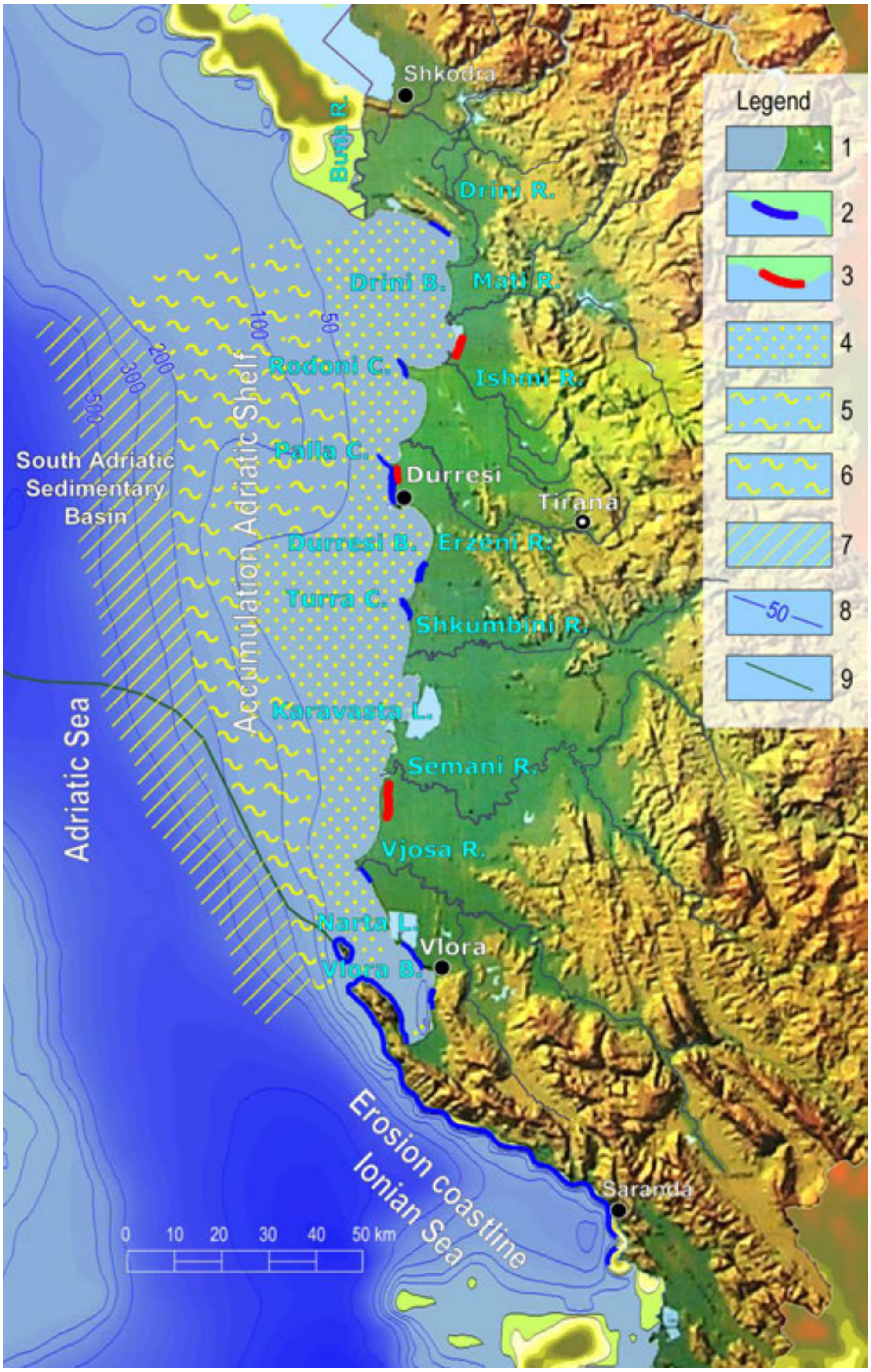


Fig. 10. Geomorphological Scheme of Albanian Adriatic and Ionian Seas coastline. (Digital Terrain Model, National Geophysical Data Center (NGDC), Geodas database, 2005.
1- Accumulative coastline; 2- Erosion coastline; 3- Submerged littoral zone; 4- Shoal shelf area with sand deposits; 5- Flat shelf area with sandy-silt deposits; 6- Inclined shelf area with muddy silt and deposits; 7- Continental slope with argillaceous sediments; 8- Isobaths; 9- Western flank of the South Adriatic Sedimentary Basin.

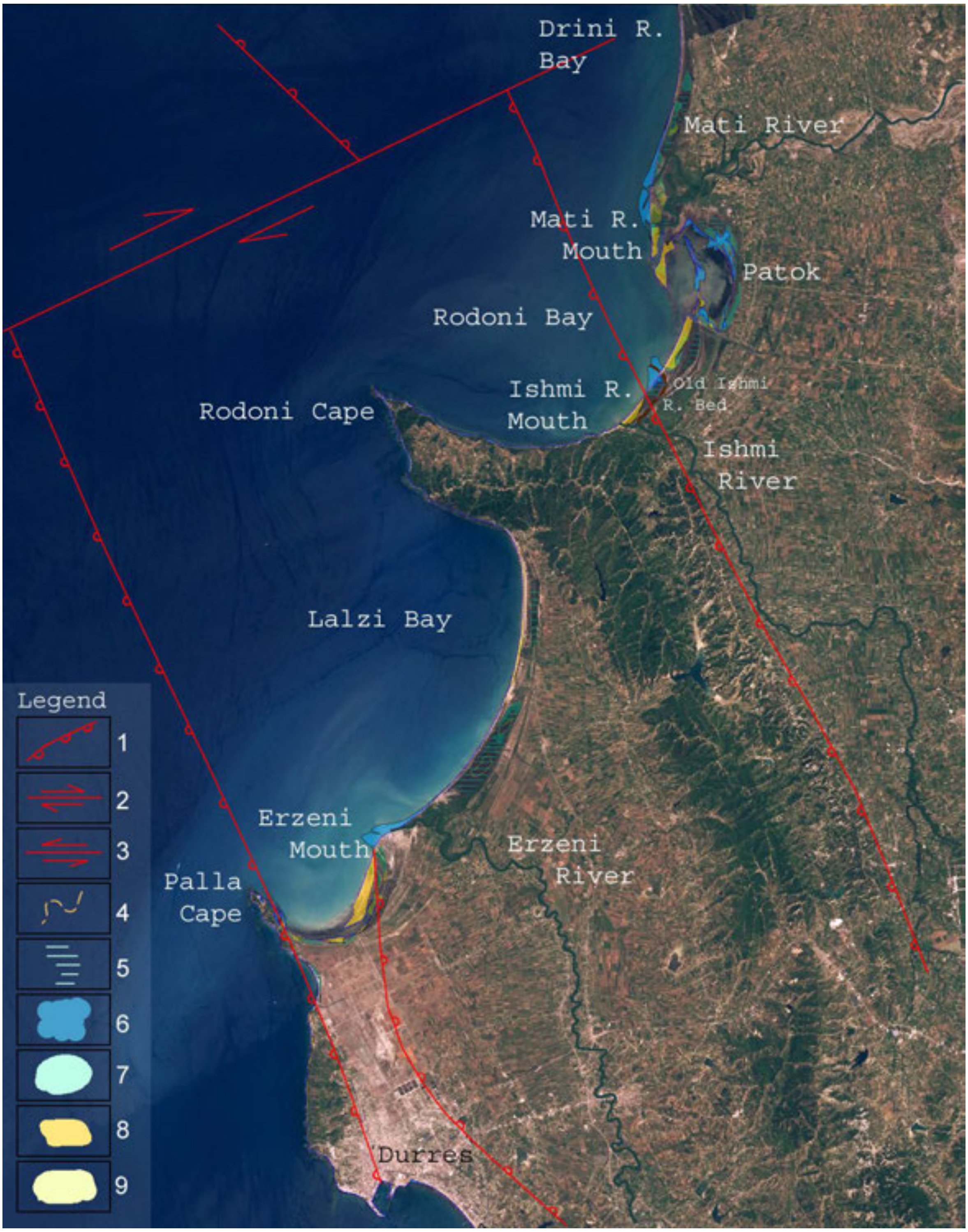


Fig. 11. Geomorphological Evolution view of the Drini Bay-Durrësi Bay coastline in the Albanian Adriatic Littoral after satellite images of the period summer 1977 & 2002 (Global Land Cover Facility Landsat, 2005; the neotectonics active reverse faults & thrusts (after Aliaj Sh. et al. 2000).
1- Active reverse fault & thrust; 2- Dextral strike-slip; 3- Sinistral strike-slip; 4- Old Mati River bed; 5- Wetlands; 6- Erosion and marine ingression; 7- Lagoon extension; 8- Coastal deposition; 9- Lagoon surface diminishing.

Fig. 12. Geomorphologic view of Shkumbini River-Vjosa River mouths coastline after satellite images of the period August 1981 & July 1989 & October 2001 (Global Land Cover Facility Landsat, 2005; the neotectonics active reverse faults & thrusts (after Aliaj Sh. et al. 2000).
1- Active reverse fault & thrust; 2- Dextral strike-slip; 3- Sinistral strike-slip; 4- Old Shkumbini River bed; 5- Coastal deposition with predecessor erosion; 6- Coastal deposition; 7- Coastal erosion; 8- Submerged littoral area.

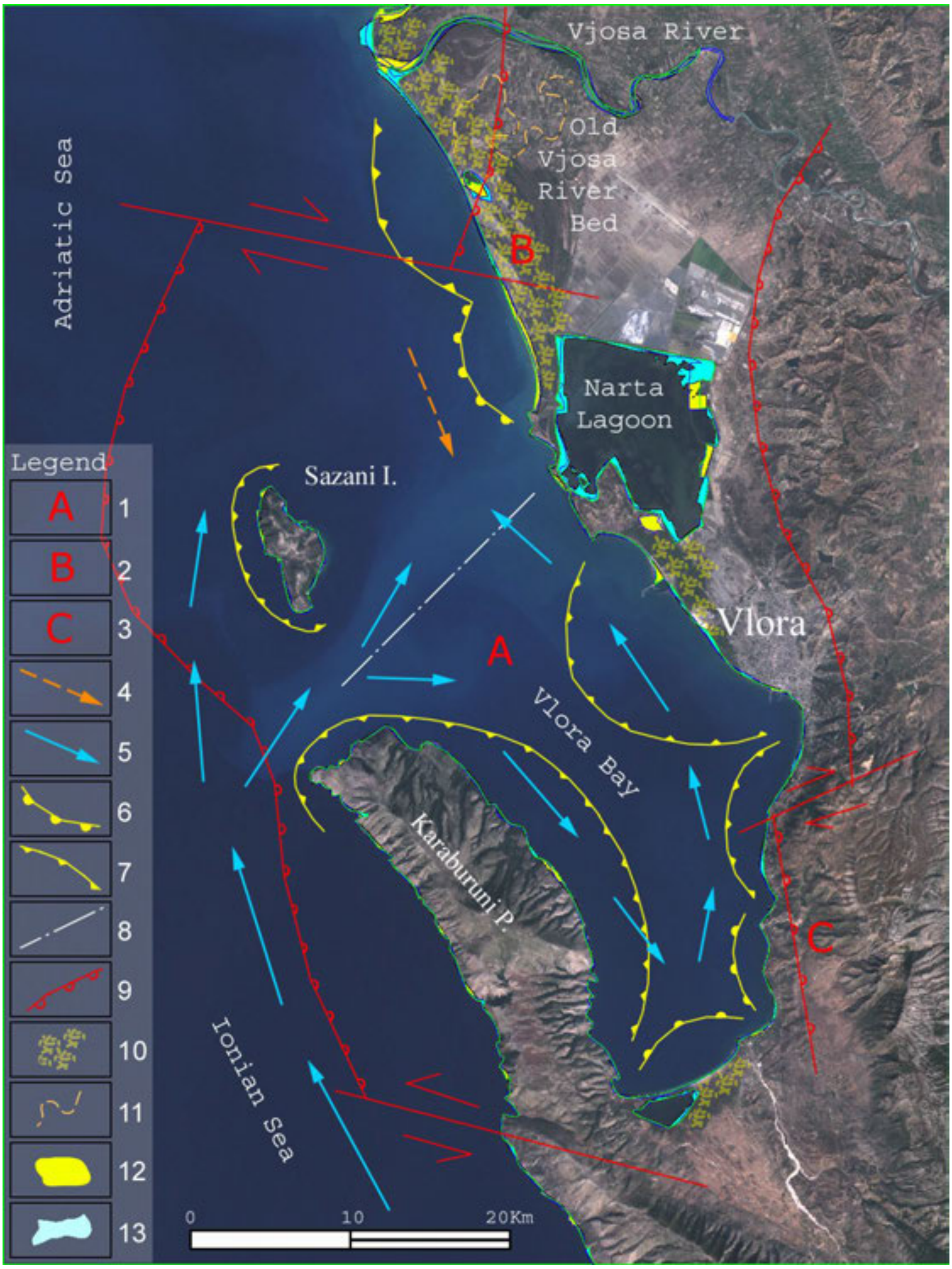


Fig. 13. General Evolution view of the Vlora Bay after satellite images of the period August 1981-July 1989-October 2001 (Global Land Cover Facility Landsat, 2005; Neotectonics active reverse faults & thrusts (after Aliaj Sh. et al. 2000).

1- Marine shoal with sand deposits; 2- Littoral with sand beaches; 3- Rocky coastline; 4- Alluvium flow; 5- Marine current direction; 6- Accumulation area; 7- Erosion area; 8- Southern edge of the sediment replacement; 9- Active reverse fault & thrust; 10- Sand; 11- Old Vjosa River bed; 12- Filling coastline; 13- Erosion coastline.

The water potentials of Albanian rivers system is Wo = 41,249.10^9 m^3. The discharge of the Albanian rivers into the Adriatic Sea varies in very wide limits, from Q_o=700-850 m^3/s for the hydrological years of a lower precipitation to Q_o=1850 2150 m^3/s for the years of a higher precipitation (Pano N. 1974, 1984, 2008). The volume of suspended material, which is transported through river network, is 65,7. 10^6 ton/year, while the turbidity Q_o=1 260 g/m^3 (Pano N. 1984). The river suspended matter deposits itself the river mouth in the Adriatic Sea. This process is very dynamic, making the Albanian river's mouths very active. Many changes of the riverbeds position formation of the coastal lagoon, etc. are observed time after time in these mouths. The wind regimes, wave refraction, sea currents, littoral sediment transport, have determined the general dynamics of the change of the Albanian coastline (Pano N. 1994). The period with the wave height of H_1=(0,1-0,2)m represents about 80% of the general cases, while the height of H=(0.2-4.5)m about 20% of them for the average multi annual year. The highest waves have a direction from Northwest to West and a maximum wave height about h=3.5-4.5 meters near shore (Pano N. et al. 1974, Meçe B. 1978). Sea level has an average daily amplitude 0,30-0,40 meters and a multi annual maximal amplitude h=1,14-1,53 meters. The winds in the Adriatic Sea change their direction and speed during a year period as a result of the typical Mediterranean climate. Intensive winds with their maximal speed of 40 – 45m/s particular of NW, W and SW direction were observed in the coastal area. Winds with varying speed form 10 to 20 m/s, have a bigger frequency on waving process. The average annual temperature of the water varies from t=17,7°C in Shëngjini to 19,2°C in Saranda bays (Albanian Climate (Tables), 1978, Mici A. etc. 1975).

Adriatic coastal line from southern city Vlora up to Shëngjini Bay, in the north, have the marine accumulation flattened littoral, the marine erosion coast, and the submerged areas, where is observed marine ingression toward the mainland. In some areas there is cliffed coastline (Aliaj Sh. 1989, 1998, 2000, Aliaj Sh. et al. 2000, Frashëri A. 1987, 1994, Frashëri et al. 1991, Geological Map of Albania 1983, Leci V. et al. 1986, Papa A. 1985).. Evolution of Albanian Adriatic coastline has a very intensive dynamics. There is observed old and present shoreline migration up to 5-10 m/year, during the period from 1918 up to present (Boriçi S. 1981). According to submarine geological mapping and geoelectrical survey data, has been determined that marine deep erosion is developed in accumulation littoral of Adriatic shoal. The sandstone banks have been mapped in western submarine anticline limbs.

Accumulative areas that represent main part of the Albanian Adriatic Sea Littoral are extended over the edge of western Albanian plains (Fig. 10). This littoral is characterized by presence of the different Quaternary (Q) deposits genetic types (Aliaj Sh. 1989, Frashëri A. et al. 1991, Leci V. et al. 1986, Papa A. 1985, Leci V. et al. 1986, Ostrosi 1977). Marine Quaternary littoral deposits, presented by fine, medium, and coarse gray—white, gray-yellow sand, silty clay and mud interbeds present marine Quaternary littoral deposits. Interbeds thickness varies from 1-10-15 meters. Very beautiful sandy beaches are extended from Drini to Vlora Bay. At the present time the shore sand knolls have a length up to 4-5 km, width 35-80 m and some meters highs. At the northern bays, the coarse sand is predominated. Toward the southern part of Adriatic coastal line, fine and medium sand are predominated. This sand belt are composed by two or three parallel onshore dunes. Towards the flat shelf depression, up to –100m depths, the sandy-silt sediments are representative. In inclined shelf area, up to –200 m depths where are also some submarine hillocks, the muddy silt deposits are distributed. Continental slope by argillaceous sediments is characterized. Lithological changes from the shore to the continental slope area are gradually. There are observed some peculiarities, of river solid load distribution in shelf area, conditioned by marine currents. Filling process is intensive, generally, in river mouths. In these accumulative coastline areas there are some relatively small erosion sectors, which are located at the river mouths. In the shoal shelf zone, at the alluvial sea floor are observed the sandy splits. Marine deep erosion zones were developed over some sectors in accumulation littoral of Adriatic shoal. These zones are located in the uplifted side of the active reverse fault & thrust. The capes of the molasses bedrocks of the littoral anticlines of the Periadriatic Depressions have represented the erosion configurations of the Albanian Adriatic sea coastline (Fig. 10). In the Abanian Adriatic Littoral are observed some submerged areas, where is observed marine transgression toward the mainland (Fig. 10). Submerged process is caused by the neotectonics activity, consequently there are observed a marine transgression. Lagoons have a total surface of about 150 $km^{2,}$. Albanian lagoons represent crypto-depressions, with the floor under the level of the sea's bottom.

In the Albanian Adriatic Littoral are observed integrated factors of the coastline evolution: neotectonic's, erosion by marine currents and accumulation of the solid river discharge and eroded shore sediments that have directly an climate change impact. This factors complex has caused important changes on the coastline geomorphology, marine shoal and littoral landscape (Boçi S. 1981,

Pano N. 1994, Simeoni U. et al. 1997, Shuitsky Yu. D. 1999). There we are analysed three most representative areas:

Drini Bay. Intensive change dynamics, Viluni Lagoon and Shëngjini portal town characterized this littoral area. The decreased sediment load of the Drini River, caused by its diversion into the Buna, has triggered coastal recession between Shëngjini and Tale, with greater intensity on the southern lobe of delta (Photo 1). Moving southwards, the coast becomes part of the sedimentary system of Mati River (Fig. 11). The coastal area between Tale and Patok can be considered as having a positive sediment budget (Pano N. 1998).

Photo 1. View of Mati River discharge in Adriatic Sea.

Karavasta Bay. The Seman and Shkumbini rivers are the main source of coastal sediments in Karavasta Bay. In ten last years, the coastline has advanced some hundred meters. Semani River mouth has changed in position in the last centuries six times and this displacements have covered on area of the littoral about 15-20 km long in a direction North-South; South-North during period 1870 to present days. In these conditions in the coast area there are two important sources of coastal sediments: the actual rivers mouth and the olds rivers mouths (Fig. 13).
Vjosa River Mouth-Vlora Bay. The general evolution map of coastline in fig. 14 is presented. Vjosa River Mouth has changed its position in the last century two times and these replacements have covered an area of the littoral about 10 km long in the northern direction (Pano N. 1994). The old mouth of this river is undergoing on important erosion process under the wave action. There are two sources of coastal sediments: first, the present Vjosa River Mouth, and second the old Vjosa River Mouth.

4. Conclusions

Based on the results of inversion of the thermologs data, recorded in deep wells and boreholes, for the evaluation of the ground surface temperature GST history and hydrometeorological data, we have arrived in following conclusions:

1. The climate at coastal plain region of Western of Albania was cooled of .6 K before of middle of 19th century. Later a warming of 0.6 K occurred, from last quarter of 19th until present-day.
2. Temperature records in northwestern mountainous region of Albania confirmed also a climate warming of 0.6 K during 20th century. At mountains regions, the warming has started about quarter of century later than at coastal plain area of western Albania.
3. Warming, mainly during the last quarter of the 20th century, is demonstrated also by meteorological data.
4. The rainfall regime changes have their consequences in the fresh water resources of the country, of surface's and underground waters.
5. Warming has caused its impact on country climate and ecosystems. There is observed a decreasing of the water resources of the country, and thermal stress in the wetlands, lagoons and lakes of Albania. on the erosion processes, and on the hydrographic regime of the Adriatic Sea. Impact it is observed first of all on the biodiversity.Coastline has an intensive change and continuously modifying its shape.
7. It is necessary to continued realizing, by a new project, of the analytical integrated studies of environmental impact of the global warming in Albanian territory and its consequences.

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OUTLOOK ON PALEOCLIMATE CHANGES IN ALBANIA.

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ABSTRACT

In the paper there are presented the results of inversion of thermologs data for the ground surface temperature history in Albania. The analysis presented in paper is based on 4 thermoplots, from different regions of Albania. The wells are located in Sedimentary Basin of Albania, at the field region in the west of Central Albania and in the ophiolitic belt in the mountainous region of the northeast Albania. Based on inversion data, it results that 3.5 centuries ago in Western Albania the climate was warmer. Later a cooling of 1 ^{o}C occurred, until 1 century ago. During the 20th century an increase of 1 ^{o}C is observed. Inexpressive climate warming in the second half of this of this century is observed in Northwestern Albania. This warming mainly after the second half of the 20 th century is presented also by meteorological data.

Keywords: Ground Surface Temperature, Paleoclimate Changes, Thermolog, Paleoclimate Reconstruction.

INTRODUCTION

Albania lies in a subtropical zone. It is a Mediterranean country. Winter is relatively short and mild, humid near the seaside areas. Summer lasts very long and it is hot and dry. To the east, in the mountain areas, the climate is Mediterranean mountainous. There, the temperature is lower than in seaside zones, and the raining decreases. Sunshine varies from 2560 hours per year in Tirana, down to 2046 hours in Kukesi City. Average yearly temperature varies from 16.5 ^{o}C in Vlora City, 11.8 ^{o}C in Kukes and 7.0 ^{o}C in the northern area of the Albanian Alps. In Albania the rainfall is about 1430 mm a year. Albanian Alps is one of the most humid territory in Europe, up to 3094 mm a year rainfalls.

The climate in Albania varies from a region to the other, according to the location compared with the seaside, to the seasons, years, and centuries. The ground temperatures are conditioned by geographical position of the area, area's geology, ground lithology, dynamics of the underground waters, meteorological conditions, and season.

The geological section of Albanian Sedimentary Basin is about 12000 m thick. Maximal geothermal gradient in this Basin has a value of 21.3 mK/m. These gradients change from one formation to others. Geothermal gradient increases up to 25 mK/m in the ophiolitic belt of the Inner Albanids. Heat flow density has its highest values of 42 mW.m $^{-2}$ in the Albanian Sedimentary Basin and 60 mW.m $^{-2}$ in ophiolitic belt (3, 4, 5, 6, 7).

Analyzing some thermoplots of different wells in Albania, it resulted a useful information to evaluate the

paleoclimate changes until a thousand years ago. This information of the Ground Surface Temperature history, according to thermoplots in Albania, is analyzed in this paper.

MATERIAL AND METHODS

The study of geothermal field of Albania has been carried out based on the temperature logging in the oil and gas deep wells located in the Albanian Sedimentary Basin, also in boreholes in the ophiolitic belt. These wells, with a depth of 50 m to 6700 m, are located in different geological situations (5, 6).

Ten thermoplots were used for inversion of the ground surface temperature history. For the analysis presented in this paper we have chosen 4 thermoplots, in different regions of Albania. Well Ko-10 it is located in Sedimentary Basin of Albania, at the field region in the west of Central Albania (Fig. 1). Wells Vl-1127, Gurth-595, Krasta-1 and Ragam-168 are located in the ophiolitic belt, in the mountainous region of the northeast of the Albania. The temperature inversion for paleoclimate reconstruction done by Dr. Jan. Safanda (Vl-1127, Gurth-595, Krasta-1, Ragam-168) and Prof. Henry Pollack (Ko-10 well), using Dr. P. Z. Shen software program, adopted after GST inversion technique proposed.

Fig. 1. Map of Albania and location of the Kol-10, Vl-1127, Gurth-595, Krasta-1 and Ragam-168 wells and Tirana, Fier and Kukes Meteorological Stations.

The results of this inversion of the ground surface temperature history are correlated with the data of air and ground temperatures, which are recorded in Meteorological Stations (1, 2, 9, 10). For this correlation three stations are chosen Tirana and Fier in Central Albania and Kukes in Northwestern region of Albania (Fig. 1).

RESULTS AND DISCUSSION

The thermoplot of Kolonja-10 deep well, which is located in field's Western region of Albania, temperature trend and residual temperature anomalies are shown in fig. 2.

Fig. 2. Thermoplot of Ko-10 well in field Western region of Albania.

According to these data, climate reconstruction of the thermal field is presented in fig. 3.

Fig. 3. Ground surface temperature history according to thermoplot of Ko-10 well (according to Prof. H. Pollack calculations)

As it is seen in this figure, from the beginning of the 20 th century the seaside region of Albania is warmer. The average increase in the temperature is about 1 ^{o}C. To the contrary, from the XV th century until the end of XIXth it has cooled about 1 ^{o}C. Pre-1500 Mean Ground Surface Temperature is equal to the

To=17.9 ^{o}C, according to Prof. H. Pollack calculations. First five centuries of the second millenium are characterized by a warming of 1 ^{o}C. In this way, climate in the seaside field's part of Albania is characterized by increase and decrease alternations of the temperature. These alternations have lasted for five centuries. Change of the average yearly temperature has not been over 1 ^{o}C.

Fig. 4,5 shows a GST history according to Vl-1127, Gurth-595, Krasta-1 and Ragam-168 boreholes, which are located in the mountainous regions of Northeast Albania. Some nonessential changes are observed in these regions as to the warming trend of the 20 th century.

Fig. 4. Thermolog of Vl.-1127 borehole, located in mountainous northwestern region of Albania

Fig. 5.. Ground surface temperature history according to thermoplot of Vl.-1127, Gurth-595 and Krasta-1 boreholes.

To correlate data of GST history according to geothermal studies with the data of hydrometeorological observations, there are analyzed data from three stations that we had in disposition. These stations are located in field regions (Tirana and Fier) and in mountainous regions of Albania (Kukes), where the investigated wells are situated. Fig. 6 presents graphics of yearly average temperature of the air and ground at depth of 20 cm and 40 cm in Tirana Meteorological Station. As well known, Tirana is located in Central Albania. The warming trend, in particular after seventy years, clearly shows these graphics **.**

Fig. 6. Air and Ground Temperature Variation at Tirana Meteorological Station.

The meteorological data shows that the warming trend is not a monotone one. In short intervals are observed cooling and warming (Fig. 7). In general, by the end of 20 th century, in all Albania is observed a warming of climate. The meteorological studies have verified this phenomenon, and it has been consisted that: "Around the 1980's a warming trend is observed" (2, 8).

Fig. 7. Ground Surface Temperature variation at Kukes and Fier Meteorological Stations.

The warming period, in the field regions of Albania, is accompanied with a decrease in the rainfalls (Fig, 8).

Fig. 8. Average Annual Rainfall Quantity, Tirana Meteorological Station.

CONCLUSIONS

Based on the results of inversion of the thermologs data, recorded in deep wells and boreholes, for the

evaluation of the ground surface temperature GST history, we have arrived in following conclusions:

1. The climate in Western field's regions of Albania was warmer 3.5 centuries ago. Later a cooling of 1^{o}C occurred, until 1 century ago. During the 20 th century an increase of 1 ^{o}C is observed.
2. Temperature records in Northwestern Mountainous region of Albania confirmed inexpressive climate warming in the second half of this of this century.
3. This warming, mainly after the second half of the 20 th century, is demonstrated also by meteorological data.

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UNIVERSITETI POLITEKNIK I TIRANËS
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KONFERENCA KOMBËTARE
„TRANSFERIMI I TEKNOLOGJISË TË AVANCUAR URA E RRUGËS SONË TË PËRBASHKËT“

Tiranë, 31 Tetor 2011

TRANSFERIMI I TEKNOLOGJIVE MODERNE PËR SHFRYTËZIMIN INTEGRAL DHE KASKADË TË ENERGJISË GJEOTERMALE NË SHQIPËRI

Alfred FRASHERI[1], Bashkim ÇELA[1], Angjelin SHTJEFNI[2], Salvatore BUSHATI[3], Niko PANO[3], ,Nevton KODHELAJ[1]

MODERN TECHNOLOGY TRANSFER FOR INTEGRATED AND CASCADE USE OF GEOTHERMAL ENERGY IN ALBANIA

Platform for the modern integrated and cascade use of geothermal energy of low enthalpy in Albania is presented in the paper. Geothermal resources in Albania are located in limestone's reservoirs, in sandstone's reservoirs, and in seismo aktive belt.

Geothermal regime of Albanides, offers several ways to use the heat of the Earth: Space heating & cooling, recreation-medical treatment center, development of the ecological and historical tourism of the best European level, power generation, and salts and microelements extraction.

In the paper addressed the analysis of market and economic assessments for areas of geothermal energy utilization

Qëllimi

Jepet një platformë për shfrytëzimin e energjisë gjeotermale të entalpisë së ulët në Shqipëri. Burimet gjeotermale në Shqipëri janë përqëndruar në në rezervuarët karbonatikë, ranorë dhe në brez sizmik aktiv. Regjimi gjeotermal i Albanideve, ofron disa drejtime të shfrytëzimit të nxehtësisë së Tokës: Ngrohja dhe

freskimi i godinave dhe serave; për rigjenerimin e shëndetit të njerëzve, trajtimet mjekësore, turizmin ekologjik dhe historik në ; gjenerimi i energjisë elektrike; nxjerrja e kripërave natyrale dhe mikroelementëve. Në kumtesë trajtohet edhe analiza e tregut dhe vlerësimet ekonomike për fushat e shfrytëzimit të energjisë gjeotermale.

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1. Hyrje

Burime të shumta të energjisë gjeotermale të enthalpisë të ulët, si edhe shumë burime të ujit termo- mineral paraqesin bazën për zbatimin e suksesshëm të teknologjive moderne në Shqipëri, për të arritur efektivitet ekonomik dhe suksesin e shfrytëzimit kompleks.

Aktualisht, ka shumë studime gjeotermale, hidrogjeologjike, hidrokimike, biologjike dhe mjekësore të kryera për burimet e ujërave termominerale në Shqipëri. Rezultatet e studimeve gjeotermale të kryera në Shqipëri janë të paraqitura në hartat dhe prerjet gjeotermale. Hartat e temperaturave janë përpiluar për nivele thellësiore të ndryshme, deri në 3000m. Janë ndërtuar gjithashtu edhe Harta e Gradientit Gjeotermal, Harta e Dendësisë së Fluksit të Nxehtësisë, si edhe Harta Tematike e Zonave Gjeotermale me pozicionin e burimeve dhe puseve gjeotermalë.

Burimet natyrore me ujrat termale dhe strukturat gjeologjike me të cilat lidhen janë hartografuar gjithashtu. Në përgjithësi, këto studime dhe vrojtime janë të veçanta, të pa lidhura me njëri tjetrin. Informacioni i tyre ka shërbyer për studime dhe vlerësime krahinore në Shqipëri. Studime dhe vlerësime të tjera, të detajuara dhe komplekse kanë qenë të nevojshme për të njohur mirë burimet termale dhe të ujit mineral në planin rajonal, si edhe të tregut gjeotermal në Shqipëri. Sipas rezultateve të këtyre studimeve është bërë vlerësimi i nivelit perspektiv të zonave gjetermale. Pas këtyre vlerësimeve të

detajuara është e mundur për të filluar investimet në zonat gjeotermale perspektive për shfrytëzimimin e integruar dhe kaskadë të energjisë gjeotermale, Ky shfrytëzim duhet të realizohet me skemë të integruar të energjisë gjeotermale, me pompat e nxehtësisë gjeotermale ujë-ujë dhe me energjinë diellore për plotësim. Kjo skemë e dobishme, miqësore me mjedisin, që përdor energjitë e ripërtëritshme (energjinë gjeotermale dhe energjinë diellore), si edhe teknologjitë e reja (pompat e nxehtësisë gjeotermale ujë-ujë), është kursimtare në përdorimin e energjisë, duke realizuar edhe shfrytëzim kaskadë të saj. Skema kaskade duhet të përdoret në mënyrë që të merret dobia maksimale nga energjia gjeotermale në zonën e zgjedhur.

Shfrytëzimi i energjisë gjeotermale do të ketë një ndikim të drejtpërdrejtë në zhvillimin e rajoneve, duke rritur të ardhurat për frymë të tyre, si edhe në të njëjtën kohë të përmirësojë standardin e jetesës së njerëzve. Këto investime janë me përfitim në një periudhë të shkurtër kohe.

2. Burimet e energjisë gjeotermale në Shqipëri

2.1. Metodika

Rezultatet e studimeve gjeotermale të kryera në Shqipëri janë të paraqitura në hartat dhe prerjet gjeotermale. Hartat e temperaturave janë ndërtuar për nivele të ndryshme, deri në 3000m thellësi 1, 2, 3. Janë ndërtuar edhe Harta e Gradientit Gjeotermal, e Dendësisë së Fluksit të Nxehtësisë, si edhe Harta tematike me zonat dhe burimet gjeotermale. Burimet natyrore me ujrat termale dhe strukturat gjeologjike me të cilat ato lidhen janë hartografuar gjithashtu [1]. Janë vlerësuar rezervat gjeotermale dhe nxehtësia në vend. Janë vlerësuar edhe mundësisë e shfrytëzimit të puseve të braktisur të thellë të naftës si “Sonda Vertikale të Nxehtësisë së Tokës".

2.2. Regjimi Gjeotermal

Strukturat gjeologjike të Shqipërisë, Albanidet janë pjesë përbërëse e Brezit të Rrudhosur Alpin Mesdhetar dhe formojnë krahun jugor të tij. Ato ndahen në dy zona paleogjeografike madhore: Albanidet e Brendshme dhe Albanidet e Jashtme. Strukturat gjeologjike të Albanideve janë bartëse të rezervave të mëdha të energjisë gjeotermale të entalpisë së ulët. Në qëndrën e Ultësirës Pranadriatike në Myzeqe, dendësia e fluksit të nxehtësisë ka vlerën 42-mW/m^2 (Fig. 1). Ky fluks ka dendësi që arrin deri 60-mW/m^2 në rajonet lindore të Shqipërisë, në brezin e shkëmbinjve ofiolitikë. Rritja e temperaturës me thellësinë bëhet me gradient gjeotermal rreth 1.87 ^{o}C/100m në rajonin e Myzeqesë (Fig. 2). Në rajonet jugore të vendit, gradienti gjeotermal ka vlera më të ulta, deri 1.15-1.3 ^{o}C/100m. Drejt rajoneve veri-lindore dhe jug-lindore të Shqipërisë, gradienti gjeotermal rritet dhe arrin vlera deri 2.35 ^{o}C/100m. Temperaturat luhaten nga një vlerë më e vogel 6.7°C deri 18.8^{o}C, mesatarisht 16.4^{o}C në thellësinë 100 m dhe arrijnë deri 105.8°C në thellësinë 6000m (Fig. 3, 4, 5).

2.3. Zonat dhe rezervuarët gjeotermale

Midis energjive të rinovueshme, të ujit, të rrezatimit diellor, erës e biomasës, zë vend edhe nxehtësia e Tokës. Në Shqipëri ka shumë burime dhe puse të ujrave termomineralë të entalpisë së ulët. Ujërat e tyre kanë temperaturë që arrijnë deri 80.0 ^{o}C (1, 2, 3, 4, 5) (Fig. 6, Tab. 1).

Burimet dhe puset gjeotermalë në Shqipëri

Tab. 1

Lloji i burimit	Vendndodhja	Tempe-raturat [°C]	Kripëra [mg/l]	Prurja [l/sek]
Burim natyror	Llixha Elbasan, Peshkopi, Krane (Sarandë),Bënjë (Përmet), Kapaj (Mallakastër), Shupal (Tiranë), Sarandoporo (Leskovik), Tërvoll (Gramsh), Mamurras (Tiranë).	21-60	0.3-26	10-40

Puse të thellë në rajonet	Kozan, Ishëm, Galigat, Bubullimë, Ardenicë, Seman, Verbas.	29.3-80.0	1-19.3	0.9-18

Nga puset e thellë, uji termal vjen nga thellësitë (800-3000)m, nga rezervuarë karbonatikë ose ranorikë.

Burimet dhe puset termale janë të vendosur në tri zona gjeotermale: Zona e **Krujës**, e **Ardenicës** dhe e **Peshkopisë**. Veç këtyre ka edhe burime të veçantë, në disa vende të tjera.

Zona gjeotermale e Krujës është zona me rezervat më të mëdha gjeotermale. Ajo ka një shtrirje të përgjithëshme prej 180 kilometra dhe gjerësi 4-5 kilometra, si edhe ka rezerva të identifikuara $5.9x10^8$-$5.1x10^9$ GJ. Kjo zonë fillon nga bregderi i Adriatikut në veriperëndim të Tiranës dhe vazhdon në jugelindje të Shqipërisë edhe në territorin grek.

Zona gjeotermale e Ardenicës ndodhet në Ultësirën Bregdetare të Shqipërisë, ne veri të Fierit. Uji fontanon në puset nga shtresat ranore në thellësi, duke patur në sipërfaqe temperaturë rreth 32-38^{o}C, dhe prurje 15-18 l/sek. Në puset e Semanit ka fontanuar ujë me temperaturë deri 80^{o}C, njëri prej të cilit tani ndodhet i zhytur në det.

Zona gjeotermale e Peshkopisë ndodhet rreth 2 km në juglindje të qytetit të Peshkopisë. Atje ndodhen disa burime pranë njëri tjetrit. Prurja e disa burimeve arrin deri 14-17 l/sek. Temperatura e ujit arrin deri 43.5^{o}C.

3. Drejtimet për shfrytëzimin e energjisë gjeotermale të entalpisë së ulët në Shqipëri

Regjimi gjeotermal i strukturave gjeologjike në Shqipëri dhe potenciali i nxehtësisë së Tokës ofrojnë disa drejtime të shfrytëzimit të energjisë gjeotermale, që sipas rëndësisë dhe kontributit të tyre në bilancin energjetik të vendit [1, 2, 3]:

3.1. Ngrohjen dhe freskimin e mjediseve duke shfrytëzuar nxehtësinë e shtresave pranësipërfaqësore të Tokës, me anën e sistemeve moderne dhe më efektivitet të lartë ekonomik “Pus - Këmbyes Nxehtësie - Pompë geotermale nxehtësie”. Një këmbyes i nxehtësisë, koaksial ose në formë U-je instalohet në shpime 30-150 m të thellë. Uji që qarkullon nëpër këtë këmbyes, ose uji i marrë në shtresa ujëmbajtëse pranësipërfaqësore nxjerr nxehtësinë nga shtresat e Tokës. Shfrytëzimi i energjisë gjeotermale për ngrohje edhe në Shqipëri, është një nga rrugët për të kontribuar në bilancin aktual të burimeve energjitike të vendit.

3.2. Shfrytëzimi integral i energjisë së ujërave gjeotermale, së bashku me energjinë diellore dhe të erës, si edhe në mënyrë **kaskade** nga temperaturat më të larta deri sa uji të ftohet në temperaturën e mjedisit, kur ujërat termale nuk kanë më potencial termal të nxjerrshëm. Qendrat Gjeotermale moderne që mund të ndërtohen në zonat e burimeve termomineralë në Shqipëri duhet të jenë komplekse, duke pasur hotel-klinikë me pishina më ujë të ngrohtë gjithë vitin, vaska për banja termale dhe kabina për sauna, sheshe dhe salla sportive e për masazhe, salla për konferenca, etj. në mënyrë që të shërbejnë për ripërtëritjen e organizmave të njerëzve të shëndoshë, për mjekimin e pacientëve me sëmundje të ndryshme, si edhe për ekoturizëm (Fig. 7). Pranë këtyre qendrave të ndërtohen sera për kultivimin e perimeve, luleve dhe fidanëve të pemëve të ndryshme, basene për kultivimin e mikroalgave, si të spirulinës, dhe rritjes së peshqve, impiante për degazimin e ujërave termomineralë dhe nxjerrjen e kripërave natyrale, fusha të mbjella me asparagus. Ujërat e pijshëm minerale mund të industrializohen për tu përdorur nga popullsia.

Ndërtimi tërësor ose pjesor i objekteve dhe instalimeve të treguara më lart tashmë është projektuar për secilin burim në Shqipëri, në varësi të parametrave gjeotermalë dhe gjeografikë.

3.3. Përdorimi i puseve të thellë të braktisur të naftës dhe të gazit si "***Sondë Vertikale të Nxehtësisë së Tok*ës"** për të ngrohur ujin në thellësi të Tokës**.**

3.4. Studimi i mundësisë së gjenerimit të energjisë elektrike në disa puse të thellë nafte që fontanojnë ujë me temperaturë mbi 60^{o}C, në kompleks me energjinë djellore.

Skenarët që janë propozuar për shfrytëzimin e energjisë gjeotermale në Shqipëri janë mbështetur në:

a) Teknologjitë moderne për shfrytëzimin e energjisë gjeotermale, sipas parimit të përdorimit integral dhe kaskadë të burimeve të ujërave termale.

b) Parametrat gjeotermalë të burimeve të ujërave termomineralë në Shqipëri.

Ndërtimi i qendrave komplekse moderne gjeotermale është edhe kusht për mbrojten dhe ruajtjen e mirë të mjedisit gjatë shfrytëzimit të burimeve termale. Aktualisht, ujërat termale derdhen në sipërfaqen e tokës duke patur impakt të madh mbi truallin, ujërat sipërfaqësore dhe nëntokësore, si edhe mbi biodiversitetin e zonës.

4. Tregu shqiptar i energjisë gjeotermale

Platoforma për shfrytëzimin efektiv të energjisë gjeotermale në Shqipëri është bazuar edhe në analizën e ekonomisë së tregut, duke patur disa objektiva [3]:

- Gjendja aktuale e zhvillimit gjeotermal në Europë, lidhur me aktivitetet, zbatimet, rezultatet, barrierat për hapjen e tregut gjeotermal, problemet ligjore dhe financiare, etj.
- Krahasimi midis gjendjes aktuale të krahinave të ndryshme të Shqipërisë.
- Identifikimi i qëndrimit dhe ndjenjat e grupeve që synojnë drejt shfrytëzimit të energjisë gjeotermale dhe aspektet e mjedisit.

4.1.Ngrohja/freskimi i mjediseve

Kërkesat për ngrohjen dhe freskimin e godinave janë rritur në Shqipëri. Gjatë dekadës së fundit, konsumi i energjisë elektrike për ngrohjen e godinave ka qënë 1,375 GWh/vit, ose 23,8% të totalit të energjisë elektrike të prodhuar në vend [6]. Sot kjo kërkesë është shumë më e madhe.

Në vendet e përparuara të Europës, SH.B.A., Kanada, Japoni etj. sot përdoren gjerësisht sistemet modene gjeotermale të ngrohjes/freskimit Pus-Këmbyes Nxehtësie-Pompë Nxehtësie Gjeotermale [7, 8]. Pesë instalimet e para gjeotermale kanë disa vjet që punojnë me sukses edhe në Shqipëri, duke treguar efektivitet të lartë ekonomik dhe duke kursyer eneregjinë elektrike. Kosto e instalimit të sistemeve gjeotermale është më e lartë sesa e sistemeve më kaldaja me naftë ose gaz, por sistemet gjeotermale konsumojnë shumë më pak energji gjatë punës. Vetëm me kursimet nga ky konsum më i vogël, arrihet që periudha e vetshlyerjes së investimeve për ndërtimin e sistemeve gjeotermale të jetë shumë e vogël, nga 2,2 deri 6,5 vjet. Çmimi i ngrohjes me sistemet gjeotermale është rreth 2,65 – 4,46 Euro cent/kWh, ndërsa për sistemet me kaldajë arrin 13 Euro cent/kWh, rrjedhimisht 2,9-4,9 herë më shtrenjt. Nga analiza e efektivitetit financiar rezulton se sistemet gjeotermale të ngrohes/freskimit janë sistemet më ekonomike, miqësore me mjedisin dhe kontribuojnë në përmiësimi e bilancit energjetik të vendit.

4.2. Përdorimi i ujërave termomineralë në llixha-rekreacioni, për ngrohje dhe ujë sanitar, për kultivime agrokulturash dhe akuakulturë, për përpunimin e ujit mineral të pijshëm dhe gjenerimin e energjisë elektrike.

Burime e ujërave termominerale në Shqipëri njihen qysh në lashtësi. Burimet termalë të Llixhave të Elbasanit, të njohura qysh në atë kohë për vetitë kurative shumë të mira të ujërave, me prurjen aktuale të ujit termomineral prej 15 l/s dhe temperaturën e tij 30-60^{o}C, kanë fuqi të mundshme për tu

instaluar 2.760 kW. Aktualisht, frekuentimi i këtyre banjave termale është rreth 28.000 persona-ditë/vit. Burimet e përroit të Banjës Peshkopi, me prurjen aktuale të ujit termomineral prej 14 l/s dhe temperaturën e tij në grykë 43,5 °C, kanë fuqi të mundshme për tu instaluar 1.700 kW. Qendra Balneologjike e Peshkopisë punon në mënyrë sezonale, nga 1 maji deri 15 nëntor dhe ka një frekuentim prej 106.500 persona dite/vit. Me dhjetra vizitorë ditorë frekuentojnë gjatë muajve të verës burimet termale të Bënjës në shtratin e lumit të Lëngaricës, të cilat janë të mirënjohura qysh në kohën e Perandorisë Romake, prandaj edhe vetë fshati e ka marrë emrin nga fjala “banjë”. Burimi i avullit në malin e Postenanit është shfrytëzuar nga banorët vendas për të bërë banja dhe për të mjekuar sëmundje të ndryshme. Edit’h Durham, në librin “The Burden of the Balkans”, botuar në vitin 1905, shkruan: “Përgjatë një shkëmbi, jo larg nga fshati, gjendet një burim sulfurik, ...Burimi vlerësohet shumë për mjekime të reumatizmit…”. Janë të mirënjohura edhe burimet termalë të Vromonerit në bregun e lumit Sarandaporo në jug të Leskovikut.

Ujërat termalë të këtyre burimeve deri më sot janë shfrytëzuar vetëm për qëllime kurative të sëmundjeve të ndryshme. Këto burime i kanë të gjitha kushtet të kthehen në qendra të rëndësishme ndërkombëtare rekreacioni-kurimi dhe ekoturizmi dhe turizmi kultoror dhe historik, sepse jo vetëm ndodhen në vende me bukuri të mahnitëse dhe me monmente të natyrës, por edhe pranë monumenteve kulturorë e historikë. Pranë burimeve duhet të ndërtohen Qendra Gjeotermale Komplekse moderne.

Zbatimi i koncepteve dhe teknologjive të reja në zonat ekzistuese gjeotermale në Shqipëri mund të jenë i realizueshëm vetëm në kushtet e miratimit të Ligjit të Energjisë Gjeotermale, drafti i cili është hartuar dhe paraqitur në kuadrin e realizimit të një projekti të Programit të UNDP, GEF-SGP 2003, në mënyrë që investimet të jenë të mbështetura në ligj dhe energjia gjeotermale të shfrytëzohet sipas normave dhe kërkesave teknike.

Për zhvillimin qendrave komplekse gjeotermale edhe shteti, me mjetet e mundësitë e veta, duhet të kontribuojë për tu përgjigjur strategjive të Komisionit Gjeotermal të Brukselit për futjen në shfrytëzim gjithnjë e më shumë të energjive të rinovueshme dhe asaj gjeotermale.

5. Konkluzione

1. Shqipëria ka burime të energjisë gjeotermale të entalpisë së ulët, në të cilat mund zbatohet teknologjia integrale dhe kaskadë për shfrytëzimin e saj si energji alternative, e qëndrueshme dhe miqësore me mjedisin.

2. Burimet e energjisë gjeotermale në Shqipëri përfaqësohen nga:

a) Nxehtësia e truallit, i cili ka tempeaturë mesatarisht 16,4 ^{o}C dhe Fluksi i Nxehtësisë së Tokës nga thellësia.

b) Ujërat termomineralë të burimeve natyrale dhe puseve që fontanojnë ujë me temperaturë deri 80 ^{o}C.

3. Përdorimi i sistemeve ngrohës/freskues, që shfrytëzojnë nxehtësinë e shtresave pranësipërfaqësore ose të ujërave nëntokësore të baseneve të cekta, me anën e teknologjisë moderne Pus-Këmbyes Nxehtësie - Pompë Nxehtësie Gjeotermale ujë-ujë, është drejtimi kryesor i shfrytëzimit të energjisë gjeotermale për të kontribuar në bilancin energjetik të vendit.

4. Energjia termale e ujërave termominerale duhen shfrytëzuar në mënyrë integrale dhe kaskadë, duke ngritur qendra moderne për rekreacion-trajtim mjekësor dhe ekoturizëm, ngrohjen e mjediseve dhe ujë i ngrohtë sanitar, ngrohje serash dhe kultivime agrokulturash dhe akuakulture, përpunim të ujërave mineralë për pirje, nxjerrje kripërash dhe mikroelementësh të dobishëm. Me ujin e disa puseve mund të gjenerohet energji elektrike, duke shfrytëzuar energjinë gjeotermale me anën e sistemeve binare në kompleks me atë diellore.

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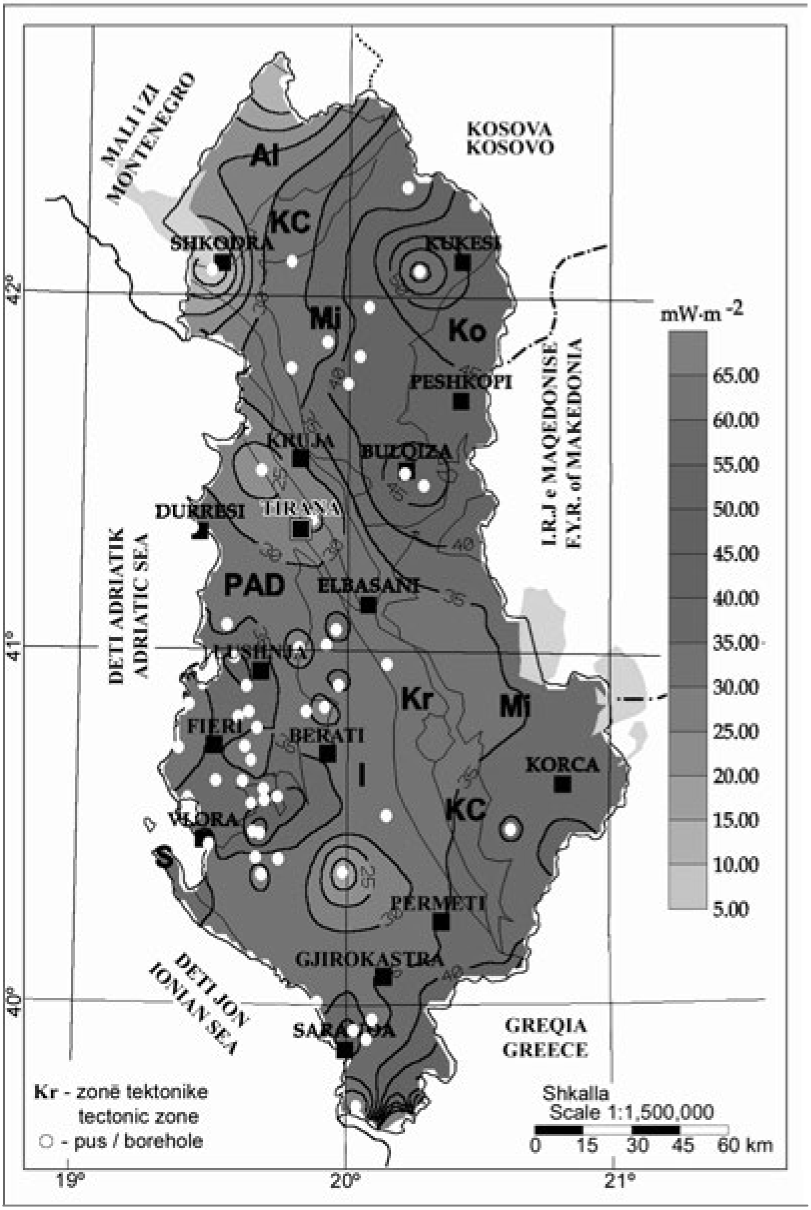

Fig. 1. Harta e dendësisë së fluksit të nxehtësisë

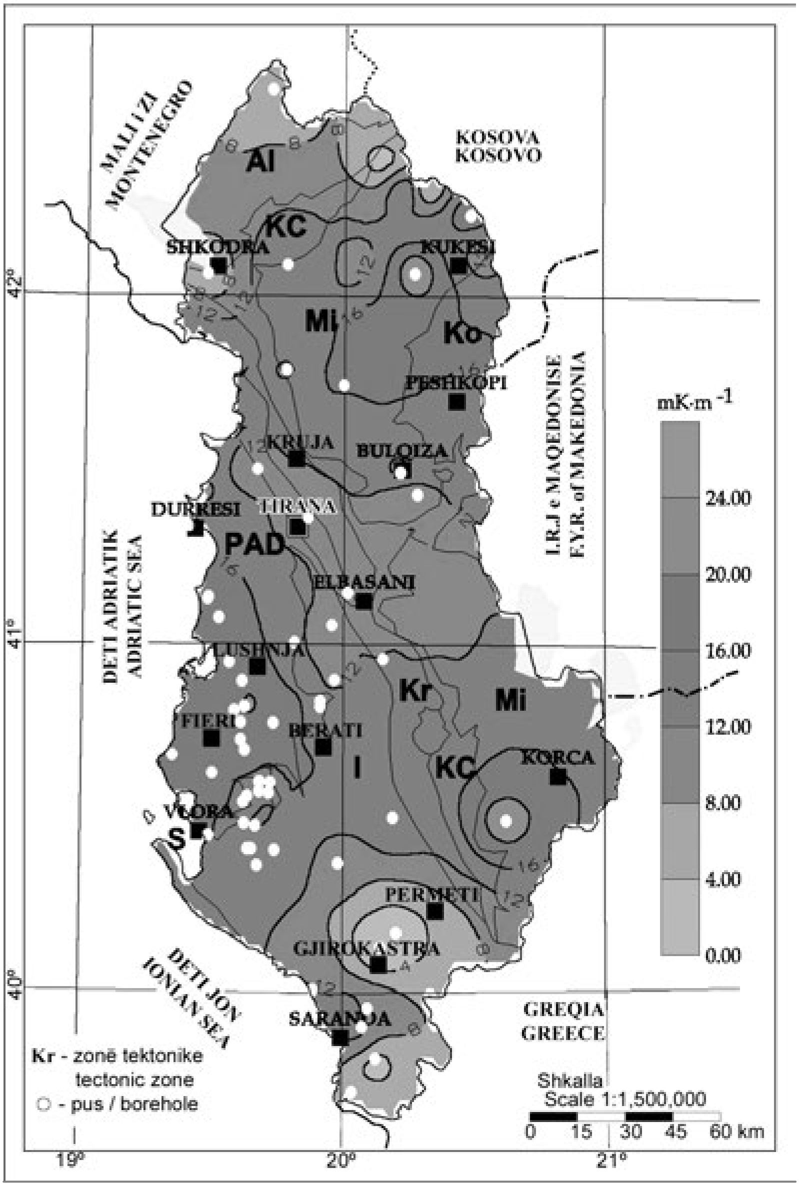

Fig. 2. Harta e gradientit gjeotermal

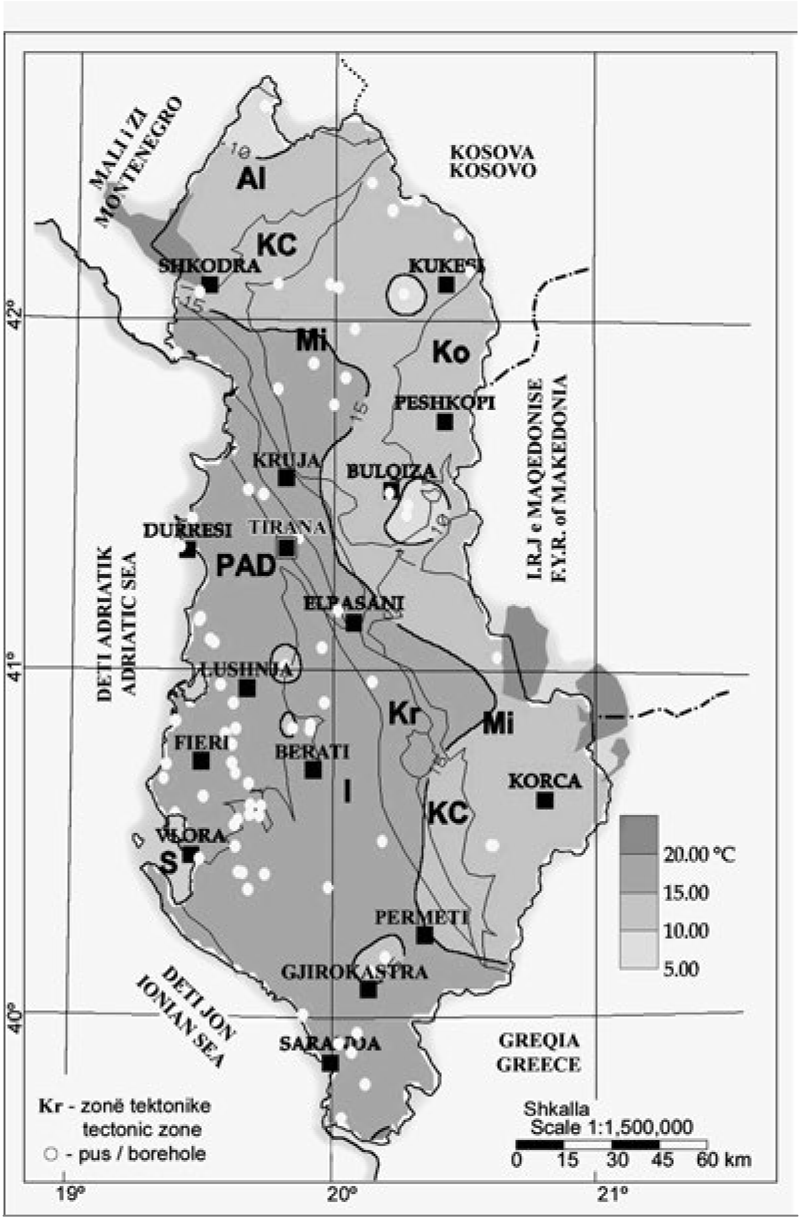

Fig. 3. Harta e temperaturës në thellësinë 100 m

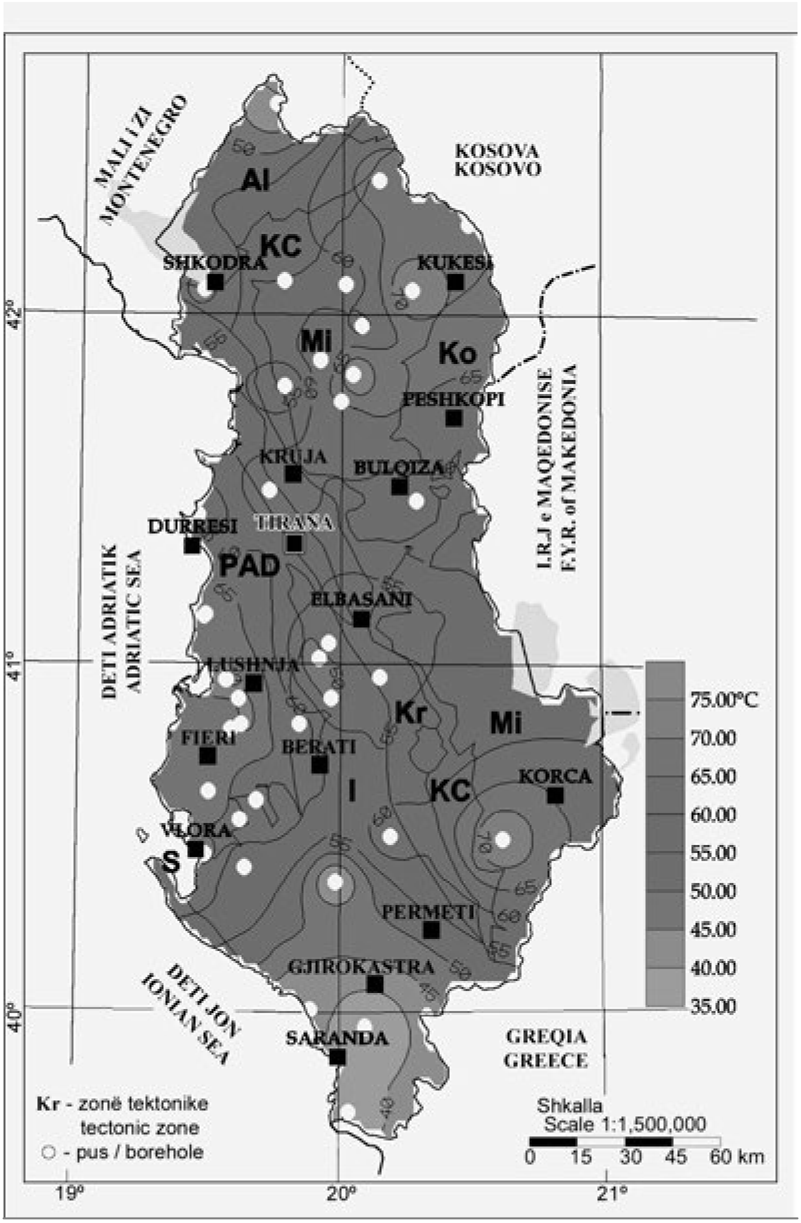

Fig. 4. Harta e temperaturës në thellësinë 3000 m

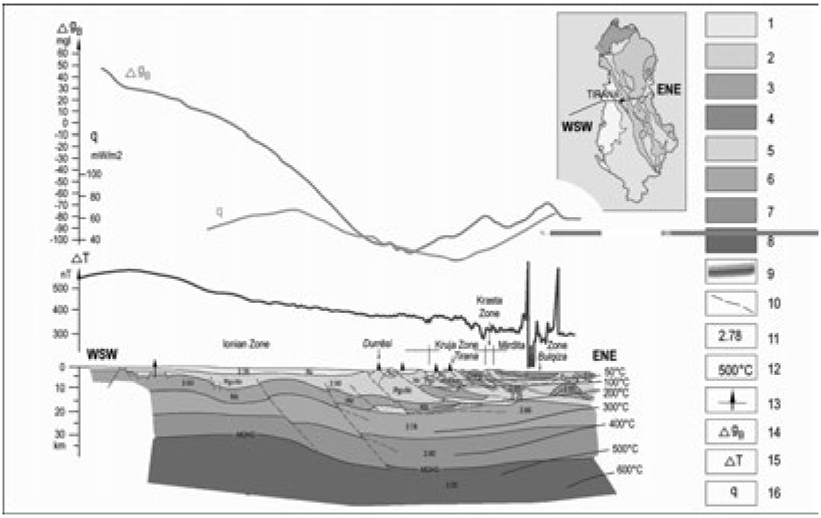

Fig. 5. Profili gjeologo-gjeofizik Albanid-1: Falco në detin Adriatik-Durrës-Tiranë- Peshkopi. [Të dhënat e gravitacionit për detin Adriatik sipas Richetti, 1980].

1. Pliocen (N_2), 2- Miocen i poshtëm (N_1)-flishi i paleogjenit (Pg_3); 3- Gëlqerorë mesozoikë (Mz); 4- Shkëmbinj ultrabazikë; 5- Kripëra; 6- Bazamenti kristalin; 7- Kore bazaltike; 8- Kufiri MOHO; 9- Thyerje e thellë; 10- Dendësia, g/cm^3; 11- Temperatura, ^{o}C; 12- Pus i thellë; ΔG_B- Anomalia Bouguer; ΔT- Anomalia e fushës totale magnetike; q-Dendësia e fluksit të nxehtësisë.

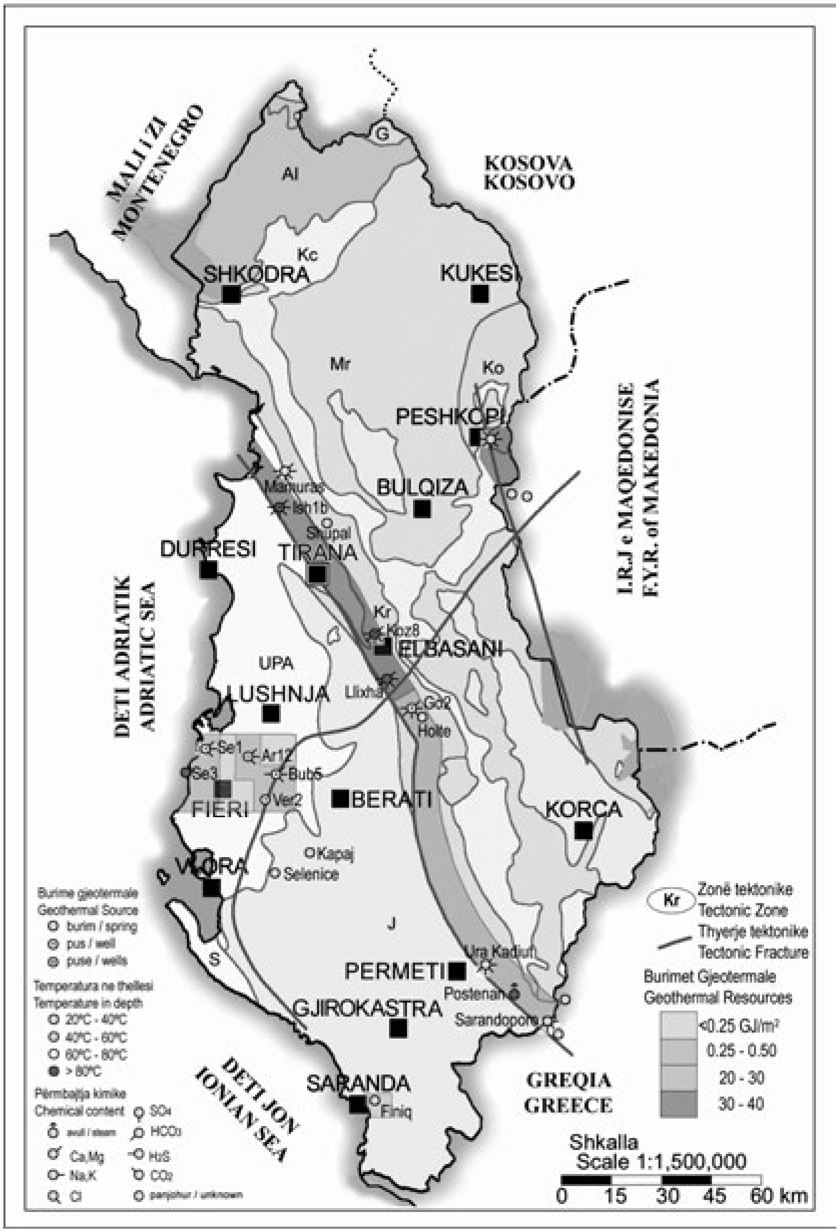

Fig. 6. Harta e zonave gjeotermale të entalpisë së ulët
në Shqipëri

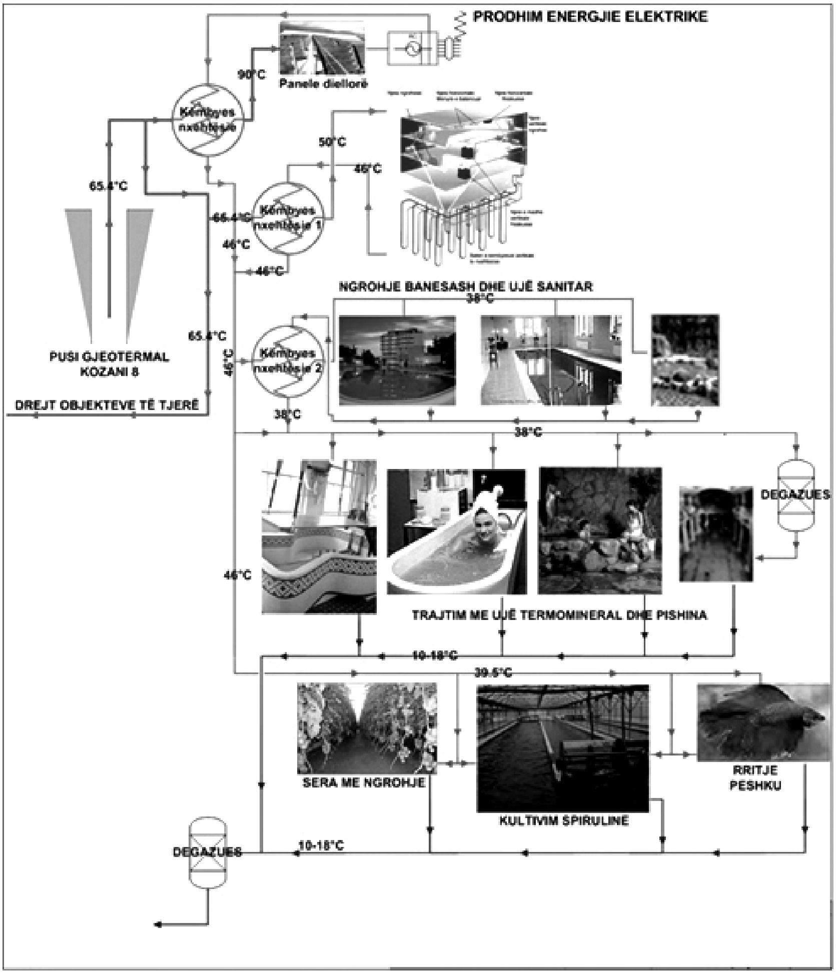

Fig. 7. Skema për përdorim integral dhe kaskadë të ujërave termomineralë të pusit Kozani-8.

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KONFERENCA KOMBëTARE

TRANSFERIMI I TEKNOLOGJISË TË AVANCUAR

URA E RRUGËS SONË TË PËRBASHKËT

Tiranë, 31 Tetor 2011

EFEKTIVITETI I SHFRYTËZIMIT TË ENERGJISË GJEOTERMALE PËR NGROHJEN/FRESKIMIN E GODINAVE NË KUADRIN E BILANCIT ENERGJETIK TË VENDIT

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Abstrakt

Kumtesa paraqet analizën e detajuar të shfrytëzimit dhe mënyrës së nxjerrjes së nxehtësisë së truallit pranësipërfaqësor për ngrohjen/freskimin e godinave dhe të serave, si edhe vlerësimin ekonomik të sistemeve gjeotermale.

Aktualisht në Shqipëri konsumohen për ngrohjen/freskimin e godinave mbi 1.375 GWh/vit, ose 23.8% e totalit të energjisë elektrike të prodhuar. Prandaj është e nevojshme që edhe në Shqipëri e Kosovë të përdoren teknologji moderne të ngrohjes se godinave, siç janë sistemet gjeotermale pus-këmbyes vertikal nxehtësie-pompë nxehtësie gjeotermale, që aktualisht janë më populloret dhe me efektivitet të lartë ekonomik në vendet e përparuara të Europës, SH.B.A, Japonisë, etj. ku ka mbi një milion instalime të tilla.

Në Shqipëri e Kosovë, si kudo, edhe shtresat pranësipërfaqësore të truallit kanë nxehtësi. Në territorin e Shqipërisë dendësia e fluksit të nxehtësisë luhatet nga 42-60 $mW.m^{-2}$. Në thellësinë 100m temperature luhatet nga 6.7^{o}C deri 18.8^{0}C. Nxehtësia e truallit ngroh edhe ujin e horizonteve ujëmbajtës. Në këtë mënyrë, ekzistojnë dy burime nxehtësie të ndodhura në thellësi të vogël: shtresat e tokës deri në thellësinë 100-150 m, si edhe uji i truallit dhe i horizonteve nëntokësore pranësipërfaqësore. Nxehtësia e këtyre dy burimeve përdoret me efektivitet të lartë për ngrohjen/fresikimin e godinave dhe të serave duke zbatuar dy teknologji:

- Pus-pompë nxehtësie gjeotermale, me të cilën nxehtësia nxirret nga toka nëpërmjet ujit që merret nga puset e cekët, ose siç quhet sistemi me "lak i hapur"
- Pus-kërbyes nxehtësie-pompë nxehtësie gjeotermale, në rastet kur në zonën e dhënë nuk ka horizonte ujëmbajtës të cekët, ose sistemi "lak i mbyllur" dhe nxehtësia nxirret nga shtresat. Këmbyesit mund të jenë vertikale ose horizontalë.

Çmimi i energjisë ngrohëse i sistemit gjeotermal luhatet 2,65 deri 4.46 cent/kWh, përkatësisht për sistemet "lak i hapur" dhe "lak i mbyllur", ndërsa për sistemin me kaldajë me naftë çmimi arrin deri 13 cent/kWh. Periudha e vetshlyerjes së investimit është 2.2 vjet për sistemin "lak i hapur" dhe 5 vjet për sistemin "lak i mbyllur". Analiza ekonomike e kryer argumenton se sistemi gjeotermal është më ekonomiku. Në Shqipëri, deri më sot janë ndërtuar katër instalimet e para gjeotermale.

Fjalët kyç: Energji gjeotermale, ngrohje e godinave, pompat e nxehtësisë gjeotermale, përdorim i drejtpërdrejtë, dendësi e fluksit të nxehtesisë.

1. Hyrje

Nxehtësia e tokës është energji alternative e qëndrueshme, miqësore me mjedisin, prandaj edhe potenciali real i energjisë gjeotermale mund dhe duhet shfrytëzuar edhe në Shqipëri. Shfrytëzimi i energjive të rinovueshme është prirja e sotme në vëndet e përparuara të botës, për disa arësye: së pari per te plotësuar kërkesat energjetike qe nuk plotësohen nga burimet energjetike të lëndëve djegëse dhe së dyti, janë energji miqësore për mjedisin. Gjatë shfrytëzimit të energjive të rinovueshme nuk çlirohen gazra që krijojnë efektin serë dhe nuk kanë impakte negative të mëdha mbi mjedisin, madje shpesh herë ndikojnë për përmirësimin e ekosistemeve.

Albanidet, që përfaqësojnë strukturat gjeologjike në territorin shqiptar, kanë fluks gjeotermal të aftë për tu vënë në shfrytëzim. Në Shqipëri ka edhe shumë burime dhe puse të ujrave termale, të energjisë gjeotermike të entalpisë së ulët, të cilët japin ujëra me temperaturë deri 65.5 ^{o}C dhe me debite deri 15 l/sek. Këto janë burim i energjisë së rinovueshme, që duhet te fillojë të shfrytëzohet në Shqipëri. Për të filluar shfrytëzimin e kësaj energjie në Shqipëri, duhet të sensibilizohet opinioni publik, administrata publike, komuniteti i biznesit dhe investitorët shqiptarë për efektivitetin e saj.

2. Shtrimi i problemit

Aktualisht në Shqipëri ekzistojnë studime gjeotermike, hidrogjeologjike, hidrokimike dhe biologjike të ujërave termale, si edhe studime mjekësore. Fakulteti i Gjeologjisë dhe i Minierave, Universiteti Politeknik i Tiranës, botoi në muajin tetor 2004 "Atlasi i burimeve të energjisë gjeotermale në Shqipëri", si edhe në majin e vitit 2010 monografinë "Burimet e energjisë gjeotermale në Shqipëri dhe platformë për shfrytëzimin e saj", në kuadrin e Programit Kombëtar për Kërkim e Zhvillim "Pasurite Natyrore" (2003-2005) dhe "Uji dhe energjia" (2007-2009) (Frashëri A. etj. 2004, 2010). Në Atlas argumentohet se strukturat gjeologjike të Shqipërisë janë bartëse të rezervave të mëdha të energjisë gjeotermale të entalpisë së ulët. Mbështetur në kapacitetet e energjisë gjeotermale në Shqipëri, si edhe në përvojën boterore të shfrytëzimit të kësaj energjie me teknologji moderne dhe me efektivitet ekonomik të lartë, tërheqim vëmendjen e komunitetit të biznesit shqiptar se ka mundësi të krijoje bisnese të reja fitim prurëse në disa drejtime:

1. **Shfrytëzimi integral dhe kaskadë i nxehtësisë** së ujërave gjeotermale. Ky shfrytëzim i ujërave termale të burimeve ose të puseve lehtësohet nga fakti se ato përgjithësisht ndodhen në zona të zhvilluara nga ana urbane në Shqipëri. Deri tani vetëm disa ujëra të burimeve termale, si ato të Lixhave në Elbasan, Në Bilaj të Fushë Krujës, të Peshkopisë etj shfrytëzohen vetëm për kurimin e sëmundjeve të ndryshme, por në mënyrë primitive, si koncept dhe si mundësi zhvillimi. Këto ujëra mund të shfrytëzohen me efektivitet të lartë ekonimik për ekoturizmin gjeotermal, mund të ndërtohen hotele me pishina me ujë të ngrohtë, me sauna, me salla e fusha sportive, me lokale argëtimi, klinika mjekësore moderne, për të tërhequr edhe pacientë të huaj, që duan të shfrytëzojnë vetitë e rralla kuruese të shumë ujërave termave të vendit tonë. Për ngrohjen e serave dhe zhvillimin e akuakulturës rritje rasati të peshve dekorative dhe të rrallë, si edhe të algave me të cilat prodhohen pomadat më të shtrenjta për shumë sëmundje dhe kozmetike. Nga këto ujëra mund të nxirren kripëra natyrale dhe e mikroelementë të dobishëm, si edhe të industrializohen ujëra minerale të veçantë.

2. Ngrohja dhe freskimi i banesave me sistemin moderne *pus-këmbyes vertikal nxehtësie-pompë gjeotermale nxehtësie*. Rëndom, kur bëhet fjalë për energjinë gjeotermale, njerëzit nënkuptojnë vetëm ujërat e ngrohta të burimeve. Kjo është një pjesë e të vërtetës. Por këto ujëra janë zakonisht të rrallë dhe të pakët. Ajo që ka kudo dhe në sasi të mëdha është nxehtësia e shtresave të tokës që nga pjesët pranësipërfaqësore e deri në thellësi të mëdha. Kësisoj, burimi kryesor i energjisë gjeotermale është nxehtësia e këtyre shtresave. Ky duhet të jetë drejtimi kryesor i përdorimit të energjisë

gjeotermale është shfrytëzimi i nxehtësisë së shtresave të Tokës. Sistemet ngrohës/freskues gjetermalë, për të njëjtën kapacitet termik, duke shfrytëzuar nxehtësinë e Tokës, konsumojnë mesatarisht mbi 3 herë më pak energji elektrike, në krahasim me kondicionerët me pompa nxehtësie ajër-ajër, që përdoren sot në vendin tonë, ose ngrohja me sistemet gjeotermale është mbi katër herë më të lirë sesa ngrohja me kaldajë me naftë.

Kërkesa gjithnjë e në rritje të energjisë për ngrohjen dhe freskimin e banesave në Shqipëri, që në vitin 1999 zinte 23.8% të totalit të energjisë elektrike të prodhuar në vend dhe sot është akoma më tepër (Fig. 1) (Strategjia Kombëtare e Energjisë), si edhe shkuarja qoftë edhe gradualisht drejt zbatimit të normave europiane për ngrohjen e banesave, për të lënë mprapa ngrohjen vetëm të një dhome nga shqipëtarët në shekujt e varfërisë së tyre, na nxitën të mendojmë për të kontribuar në zgjidhjen e këtij problemi. Çështja bëhet akoma më problemore me përdorimin e naftës e gazit për ngrohje, të cilat veç të tjerash emetojnë në atmosferë sasi të mëdha gazi CO_2.

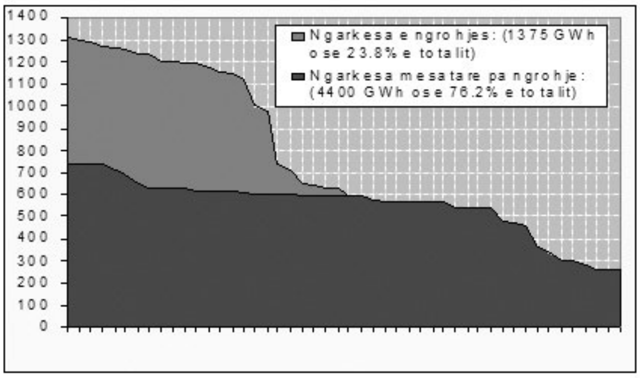


Fig. 1. Kurba e vazhdueshmerisë vjetore të ngarkesës elektrike pa ngrohje me ngrohjen për vitin 1999 (Energjia elektrike totale e furnizuar 5775 GWh), (Agencia Kombëtare e Energjisë).

Ngrohja e godinave publike dhe shtëpive të banimit, si edhe serave me anën e nxehtësisë së shtresave pranësipërfaqësore të tokës është një nga drejtimet aktuale që po përjeton një bum të madh në vendet e Evropës dhe në SH.B.A., Kanada, Japoni etj. Për këtë qëllim, përdoret sistemi pus - këmbyes nxehtësie - pompë nxehtësie gjeotermale, i cili shfytëzon burimet vendore të energjisë, siç është nxehtësia e shtresave pranësipërfaqësore, për ngrohjen e banesave.

Burime nxehtësije mund të jenë:

a) Shtresat pranësipërfaqësore deri në thellësinë 100-150 m.
b) Uji nëntokësor, i ngrohur nga nxehtësia e shtresave.
c) Uji i liqeneve dhe i deteve

Nxehtësia nga shtresat e tokës merret me anën e këmbyesve të nxehtësisë, të disa tipave. Një këmbyes vertikal i nxehtësisë (Fig. 2,a), koaksial ose në formë U-je, instalohet në shpime 30-150 m të thellë. Fluidi që qarkullon nëpër këtë këmbyes nxjerr nxehtësinë nga shtresat e Tokës. Këto sisteme këmbyesish nxehtësie emërtohen ***me qark të mbyllur.*** Në Shqipëri, ku këto shtresa kanë temperaturë 5-20°C në këmbyes mund të qarkullojë ujë, sepse nuk ka rrezik ngrirje të tij. Këmbyes të shumfishtë, të instaluar në bateri pushesh përdoren për të ngrohur godina të mëdha ose blok godinash publike.

Në zona ku përreth godinës ka tokë të lirë, mund të përdoret këmbyes nxehtësie i vendosur horizontalisht, në transhe 1-2-1.8m të thellë, i cili mund të ketë forma nga më të ndryshmet. Natyrisht, efektiviteti i këtyre këmbyesve të nxehtësisë është më i ulët, sepse në to ka ndikim të madh ndryshimi i klimës.

Kur shfrytëzohet nxehtësia e ujërave nëntokësore ose e liqeneve e deteve, sistemet emërtohen ***me qark të hapur*** (Fig. 2.b). Nga nëntoka ose rezervuari merret uji, i cili dërgohet drejtpërsëdrejti në pompën e nxehtësisë ujë-ujë. Kur merret uji i detit, për të evituar korrozionin, uji i detit qarkullon

nëpër një këmbyes nxehtësie. Pasi kalon në pompën e nxehtësisë, uji injektohet përsëri në shtresat nëntokësore, që të ruhen rezervat ujore të basenit dhe niveli dinamik i ujit nëntokësor.

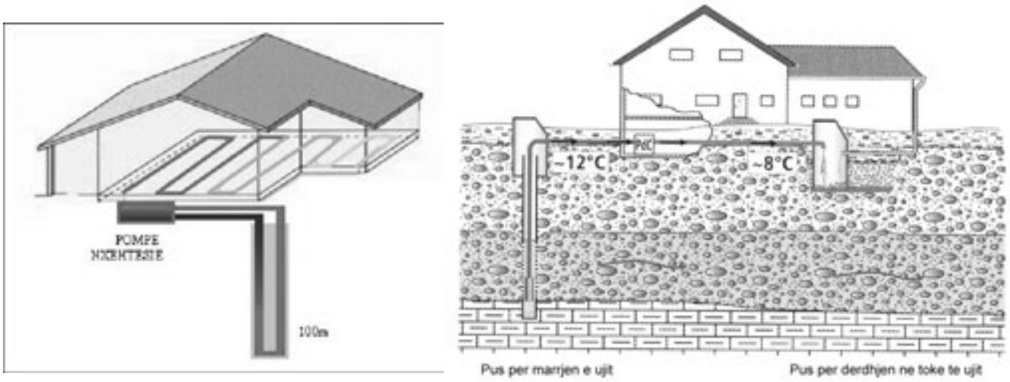


Fig. 2. Nxjerra e nxehtësisë nga nën toka: Sistemi me qark të mbyllur-këmbyes vertikal nxehtësie në pus 100 m të thellë (2.a) dhe skema me qark të hapur, duke marrë ujë nga nëntoka (2.b).

Aktualisht këto janë sistemet më moderne, me efektivitetin ekonomik më të lartë dhe konsumin më të vogël të energjisë elektrike, me teknologji më të përparuar miqësore me mjedisin dhe po bëhen gjithënjë e më shumë më popullore. Në 26 shtete në Europë dhe në SHBA, sipas të dhënave jo të plota për vitin 2005 janë montuar 900 mijë instalime gjeotermale, më fuqi 12 kW sejcila, për ngrohjen dhe freskimin e shtëpive-vila, por ka edhe mijëra instalime më fuqi deri 500-1500 kW për ngrohjen e institucioneve dhe të blloqeve të banesave komunale (Ryback L. et al. World Geothermal Congress 2005). Kapaciteti i instaluar është 15.723 MWt. Në Gjermani aktualisht ka mbi 50 mijë instalime dhe në vitin 2005 atje janë montuar 6.799 pompa gjeotermale nxehtësie dhe vetëm 1.526 kondicionerë me pompa ajër-ajër. Shëmbull tipik është edhe Zvicra, ku ka 25.000 instalime, me fuqi të pompës nga 19-40 kW, të cilët shfrytëzojnë nxehtësinë e shtresave pranësipërfaqësore të tokës me temperaturë 10^{o}C. Në Austri ka 23.000 instalime, në Suedi 200.000, në Danimarkë 43.000, në Francë 40.000, në USA 600.000 instalime etj.

3. Tabloja e energjisë gjeotermale e shtreseve pranë sipërfaqësore në Shqipëri.

Ashtu si kudo, edhe në Shqipëri shtresat pranësipërfaqësore të Tokës kanë nxehtësi. Nga analiza e gjendjes së regjimit gjeotermal të kësaj prerjeje gjeologjike, rezulton se kjo prerje ka energji gjeotermale e niveleve të tilla që lejon të shfrytëzohet nxehtësia e tyre për të ngrohur godinat (Frashëri A. etj. 2010, 2008, 2004). Kjo energji mund të shfrytëzohet me sukses për ngrohjen e godinave publike (zyra, spitale, bibioteka, shkolla, teatro e kinema, godina aeroporti etj) si edhe blloqe banesash e vila për banim, duke shfrytëzuar sistemet moderne të ngrohjes Pus - Këmbyes Nxehtësie - Pompë Gjeotermale Nxehtësie.

Sasia e nxehtësisë, temperatura në sipërfaqen e Tokës dhe gradienti gjeotermal i prerjes gjeologjike pranësipërfaqësore kushtëzohen nga gjendja e vendndodhjes gjeografike, kushtet gjeomorfologjike (pjerësia e sipërfaqes së Tokës dhe pozicioni i saj në raport me Diellin), litologjia e truallit dhe e shkëmbinjve rrënjësorë, nxehtësia specifike dhe lagështia, stina dhe moti. Sipas vrojtimeve gjeomorfologjike shumëvjeçare rezulton se mesatarisht 140.000 kalori/cm^2 nxehtësi merr trualli nga rrezatimi diellor gjatë verës në trevat fushore në Shqipëri. Sasia e nxehtësisë arrin në 120.000 kalori/cm^2 në rajonet veri-lindore malore (Gjoka L., 1990).

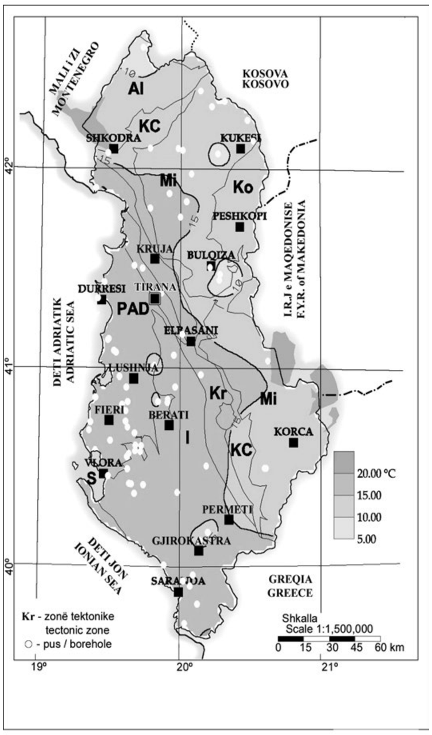
Shpërndarja e fushës termale në territorin shqiptar, në pajtim me vlerat e gradientit gjeotermal, në në pjesën e sipërme pranësipërfaqësore të prerjes gjeolgjike tregon se temperatura në thellësinë 100m ka vlera si mëposhtë vijon (Fig. 3) (Frashëri A. etj. 2004):

Temperatura në zonën bregdetare: Minimale 16.6°C; Maksimale 18,8°C; Mesatare 17.8 °C.

Temperatura në zonën perëndimore fushore-kodrinore: Minimale 17.15°C; Maksimale 18,41°C; Mesatare 18.0 °C.

Temperatura në zonat kodrinore-malore: Minimale 6.7°C; Maksimale 18,6°C; Mesatare 14.7 °C.

Në fushën e Tiranës (Rinas), temperatura është 15.5°C nga thellësia 20 deri 35m, në depozitimet kuaternare (Fig. 4) (Frashëri A. etj. 2004). Siç duket nga termograma e pusit në Rinas, nga sipërfaqja e Tokës e deri në thellësinë 20 m, më këtë zonë, temperatura e depozitimeve ndryshon në varësi të stinës dhe përcaktohet nga nxehtësia që Toka merr nga Dielli. Në dimër, temperaturat janë më të ulta, edhe në këtë pjesë të prerjes gjeologjike. Në thellësi më të mëdha, temperatura e depozitrimeve dhe e shkëmbinjve nuk varet nga stinët dhe përcakjtohet nga gradienti gjeotermal normal i zonës; për rastin e Rinasit 15.5°C. Konstatohen ndryshime anësore të temperaturës deri në 0.5°C edhe në distanca deri 500m, në të njëjtën kohë. Këto ndryshime anësore janë kondicionuar nga litologjia e depozitimeve kuaternare. Është vrojtuar se në rajonet malore të vendit, thellësia e temperaturës që përcaktohet nga rrezatimi diellor arrin deri në 50m.



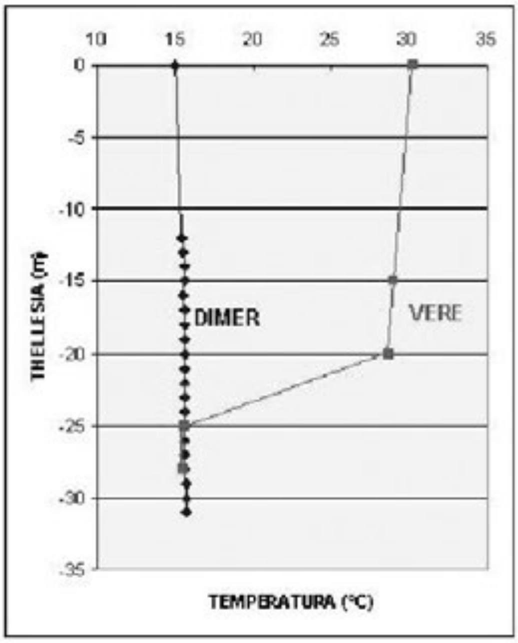


Fig. 3. Harta e temperatures e Shqipërisë, në thellësinë 100 m

Fig. 4 Termograma e pusit në fushën e Tiranës (Rinas)

Nxehtësia e shtresave pranë sipërfaqësore të Tokës kanë ngrohur edhe ujërat e rezervuarëve nëntokësorë. Në trevat fushore në perëndim të Shqipërisë, ujërat nëntokësore kanë këto temperatura: Uji i shtresave zhavorore të kuaternarit ka temperaturë 14-15 °C,ndërsa temperatura e ujit e shtresave ranore të kuaternarit është 15-16 °C. Për rrjedhoje ujinëntokësor mund të shërbejë si burim nxehtësie për pompat gjeotermale.

4. Vlerësime ekonomike për skemën ngrohëse pus - këmbyes vertikal nxehtësie - pompë gjeotermale nxehtësie.

Nga të dhënat e literaturës rezulton se kosto e investimit për sistemet e ngrohjes gjeotermale luhaten 34-216 Euro/m^2 të sipërfaqes së godinës. Kosto më e ulët është në rastet kur si burim nxehtësie shërben uji nëntokësor, për marrjen e të cilit kërkohet të shpohet pus i cekët, në te cilin mund të bëhet edhe ri-injektimi i ujit përsëri në shtresë pasi kalon nëpër pompën gjeotermale. Kosto

maksimale del kur burim nxehtësie janë shtresat pranësipërfaqësore dhe për të nxjerrë nxehtësinë kërkohet të shpohen puse deri 100m të thellë, për të vendosur këmbyesin vertikal të nxehtësisë. E krahasuar kjo kosto me atë të sistemeve me kaldajë, rezulton se ajo është rreth 35,7% më e madhe.

Sistemet këmbyes nxehtësie-Pus-Pompë Gjeotermale Nxehtësie (KN-P-PGjN) kanë marrë këtë zhvillim megjithesë kanë kosto ndërtimi më të lartë se kosto e sistemeve ngrohëse konvencionale më kaldajë me naftë. Ka disa arsye për këtë:

Konsiderata ekonomike. Kosto vjetore e "karburantit" të sistemit gjeotermal (energjia elektrike për pompën e nxehtësisë dhe pompën e qarkullimit të ujit nga pusi) janë në mënyrë të konsiderueshme shumë më të ulta sesa kosto e karburantit të një kaldaje konvencionale me naftë ose gas. Për koeficient performance KP = 3.5, kursehet deri 71% e energjisë elektrike. Kështu, koha e kthimit të shpenzimeve të KNP është më e shkurtër se koha e punës së vetë sistemit ngrohës.

Konsiderata mjedisore. Sistemi gjeotermal është një sistem mjedisor i pastër që nuk çliron gaze CO_2 ("efekti serë"), kështu që evitohet për pronarin e shtëpisë pagesa e taksës për emisionin e gazeve CO_2, e cila është në diskutim në vendet e Komunitetit Europian.

Mbështetje qeveritare. Për instalimin e sistemit gjeotermal, për shembull, qeveria japoneze jep një investim prej 200 USD për çdo kWe të pompës së nxehtësisë gjeotermale ujë-ujë, duke patur një limit të sipërm 5.200 USD. Këtë mbështetje e bën sepse përmirësohet bilanci energjetik i vendit me zbatimin e sistemeve gjeoermale të energjisë së rinovueshme.

Për një vlerësim të plotë po paraqesim një preventiv, me qëllim që të analizohen dy probleme: kosto e instalimit të sistemit dhe shpenzimet për energjinë elektrike ose për konsumin e naftës të sistemeve të ndryshme ngrohëse, sipas çmimeve aktuale në Shqipëri.

Godina: Universiteti "Fan Noli", Korçë
Sipërfaqja e përgjithëshme: 1.200 m^2; ngrohja: me kalorifere (radiatorë); kapaciteti për ngrohje 134 KW, periudha e ngrohjes 1836 orë/vit (Frashëri A. etj. 2008).
***Sistemi ngrohës*, analizohen tre variante:** Pus - pompë nxehtësie gjeotermale; Pus - këmbyes vertikal nxehtësie - pompë nxehtësie gjeotermale, kaldaje me naftë.
Në figurat 5, 6 paraqiten grafikët e kostos për konsumin e energjisë elektrike ose të naftës, si edhe kosto e përgjithëshme të instalimit dhe të konsumit të karburantit ose energjisë elektrike gjatë një dekade pune të instalimeve me sisteme të ndryshme ngrohjeje. Në fig. 7 tregohen grafikët e differences së shpenzimeve kumulative vjetore për naftë dhe energji elektrike për sistemet ngrohës dhe e kostove të instalimit të sistemeve ngrohës të ndryshëm. Duket qartë se p*eriudha e vetshlyerjes së investimeve për sistemin "pus-pompë gjeotermale nxehtësie"* është 2.2 vjet, kur investimi mbulohet vetëm me shpenzimet që do të bëheshin për naftën e kaldajës. Vetshlyerja arrin në 5 vjet kur përdoret sistemi *"pus-këmbyes vertikal nxehtësie-pompë gjeotermale nxehtësie*

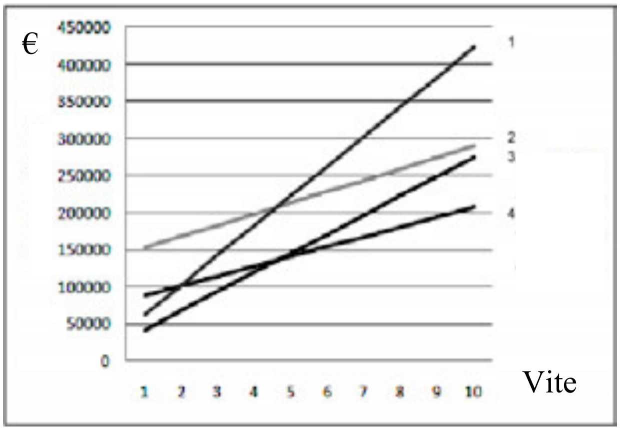


Fig. 5. Kosto e instalimit dhe e shpenzimeve vjetore për karburant dhe energji elektrike për sistemet ngrohës:

Legjendë: Seria 1: Sistemi pus-pompë nxehtësie gjeotermale, Seria 2: Pus-këmbyes vertikal nxehtësie-pompë nxehtësie gjeotermale; Seria 3: Sistemi me kaldajë, për naftë me çmim 1,2 Euro/litri; Seria 4: Sistemi me kaldajë, çmimi i naftës 0.8 Euro/litri.

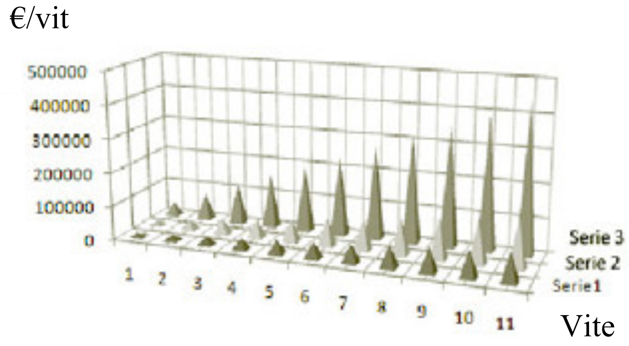


Fig. 6. Shpenzimet kumulative vjetore për naftë dhe energji elektrike për sistemet ngrohës (në Euro):
Legjendë: Seria 1: Sistemi pus-pompë nxehtësie gjeotermale, Seria 2: Pus-këmbyes vertikal nxehtësie-pompë nxehtësie gjeotermale; Seria 3: Sistemi me kaldajë.

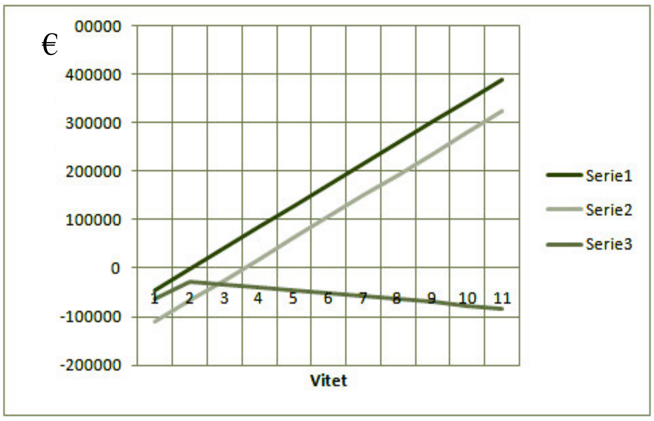


Fig. 7- Grafikët e differences së shpenzimeve kumulative vjetore për naftë dhe energji elektrike për sistemet ngrohës dhe e kostove të instalimit të sistemeve ngrohës të ndryshme (në Euro).
Legjendë: Seria 1: Sistemi pus-pompë nxehtësie gjeotermale, Seria 2: Pus-këmbyes vertikal nxehtësie-pompë nxehtësie gjeotermale; Seria 3: Sistemi me kaldajë.

Nga vlerësimet e bëra rezulton se kosto njësi e instalimit luhatet 59,3-109,3 Euro/m^2, në varësi të burimeve të nxehtësisë. Kosto më e lartë është për rastet e ndërtimit të këmbyesve vertikalë të nxehtësisë në puse. Kosto më e ulët është kur si burim nxehtësie është uji nëntokësor dhe kërkohet pus i cekët për të marrë ujin dhe për ta injektuar pasi kalon nëpër pompë.

Në figurën 8 jepet grafiku i kostos në lekë për një njësi (kW) të ngrohjes. Duket qartë se sistemi gjeotermal ka koston më të vogël se të gjitha sistemet e të tjerave.

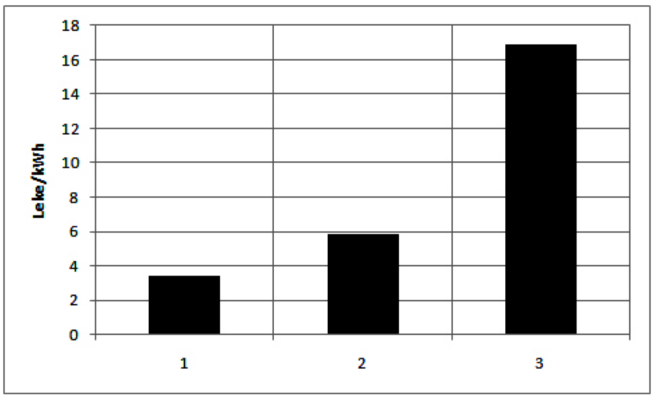


Fig. 8. Kosto në Lek/kWh për ngrohjen e godinës së Universitetit "Fan Noli"të Korçës, pas periudhës së vetshlyerjes së investimeve për instalimin e sistemit ngrohës.
Legjendë: Seria 1: Sistemi pus-pompë nxehtësie gjeotermale, Seria 2: Pus-këmbyes vertikal nxehtësie-pompë nxehtësie gjeotermale; Seria 3: Sistemi me kaldajë.

5. Thirrje për investim, në vend të përfundimeve

Zgjidhja ekonomike e problemit të ngrohjes në Shqipëri është një detyrë e ditës dhe tepër e rëndësishme, veçanërisht më kushtet e importit të sasive të mëdha të energjisë elektrike. Një ndër rrugët e duhura është përdorimi i energjisë gjeotermale. Në Shqipëri ka një bum në ndërtimet e godinave të larta shumëkatëshe. Ato ende projektohen të ngrohen me kaldaja me naftë ose me gaz, si edhe me kondicionerë ajër-ajër. Në të gjitha godinat e institucioneve shtetërore ngrohja dhe freskimi bëhet me kondicionerë ajër-ajër, spitale, konvikte, hotele, etj ngrohen me sistemin me kaldaja me naftë ose me gaz.

Për të zgjeruar këtë drejtim të ri, tashmë të hapur edhe në Shqipëri, të përdorimit të energjisë gjeotermale, që është energji e rinovueshme dhe miqësore me mjedisin, ka ardhur koha, që të dilet mbi synimet e bisnesmenëve që tregëtojnë naftë e gaz, mbi praktikat e konsumit të energjisë elektrike që paguhet nga buxheti i shtetit, ose që nuk paguhet ende. Futja e sistemeve ngrohëse dhe freskuese me anën e energjive të rinovueshme, midis të cilët atë të nxehtësisë së Tokës, duhet të fillojë të realizohet gjerësisht.

Me realizimin e këtij objektivi i bëhet apel administratës shtetërore që mbulon problemet energjetike, komunitetit të biznesit si edhe opinionit tekniko-shkencor, që të krijojnë mundësi për të bërë ngrohjen e banesave sa më ekonomike dhe sa më mirë. Shteti, me levat e veta ekonomike duhet të stimulojë futjen edhe në Shqipëri të këtyre sistemeve moderne dhe shumë ekonomike e miqësore me mjedisin. Komuniteti i biznesit duhet ti njohë dhe të investojë për ndërtimin e sistemeve pus - këmbyes nxehtësie - pompë gjeotermale nxehtësie, duke hapur rrugë për biznese të reja në plan kombëtar. Universitet teknike të shpërndajnë njohuritë për këto sisteme bashkëkohore dhe të bëhen nxitës të zbatimit të tyre në Shqipëri.

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UNIVERSITETI POLITEKNIK I TIRANËS
KONFERENCA KOMBËTARE
TEKNOLOGJITE E AVANCUARA
RRUGA JONE E ZHVILLIMIT
Tiranë, 31 Tetor 2011

SHFRYTËZIMI I ENERGJISË GJEOTERMALE PËR NGROHJEN/FRESKIMIN E MJEDISEVE, NË PAJTIM ME DIREKTIVT E KOMISIONIT EUROPIAN TË ENERGJISË GJEOTEMALE

Alfred FRASHERI
Fakulteti i Gjeologjise dhe i Minierave
Universiteti Politeknik i Tiranës

Tiranë, më 31 tetor 2011

SHTRIMI I PROBLEMIT

Energjia termike e konsumuar për ngrohjen e banesave zë një vend të rëndësishëm në bilancin ekonomik të vendit.

Rritja e kerkesave per energji per ngrohjen dhe freskimin e godinave te banimit dhe publike.

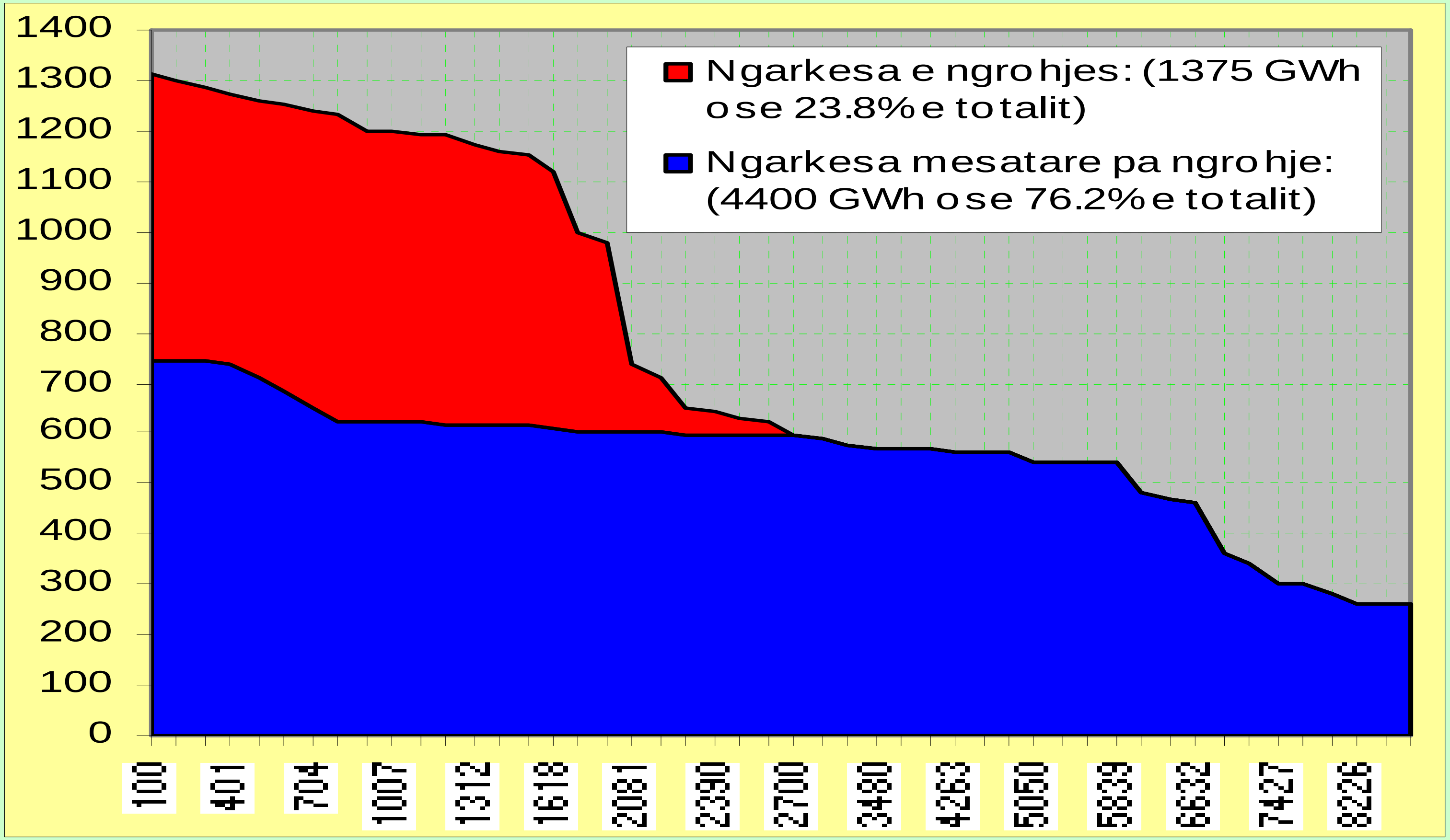
Synimi per te zbatuar standardet Evropiane per kete problem,

Lënia mprapa e ngrohjes vetëm të një dhome nga shqipëtarët në shekuj,

MW

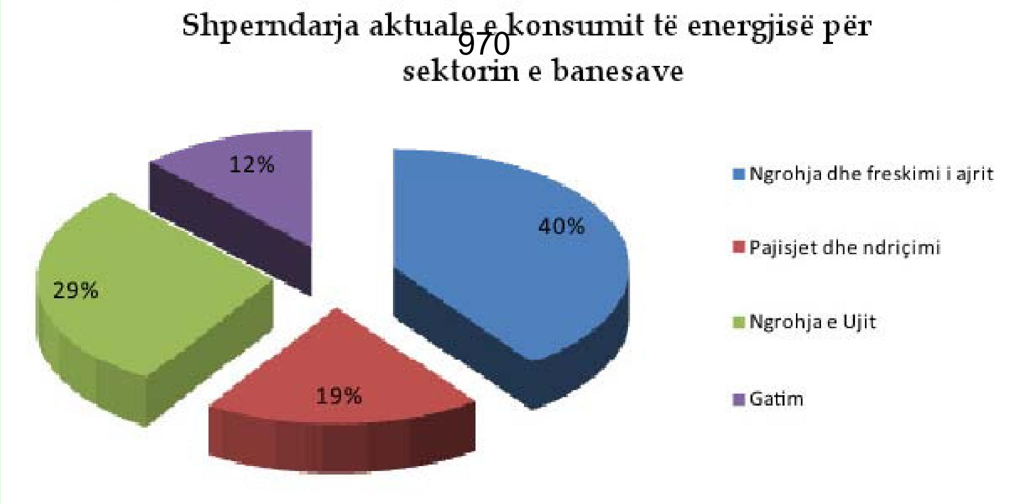
Energjia per ngrohje, 1375 GWh, 23.8% e prodhimit total

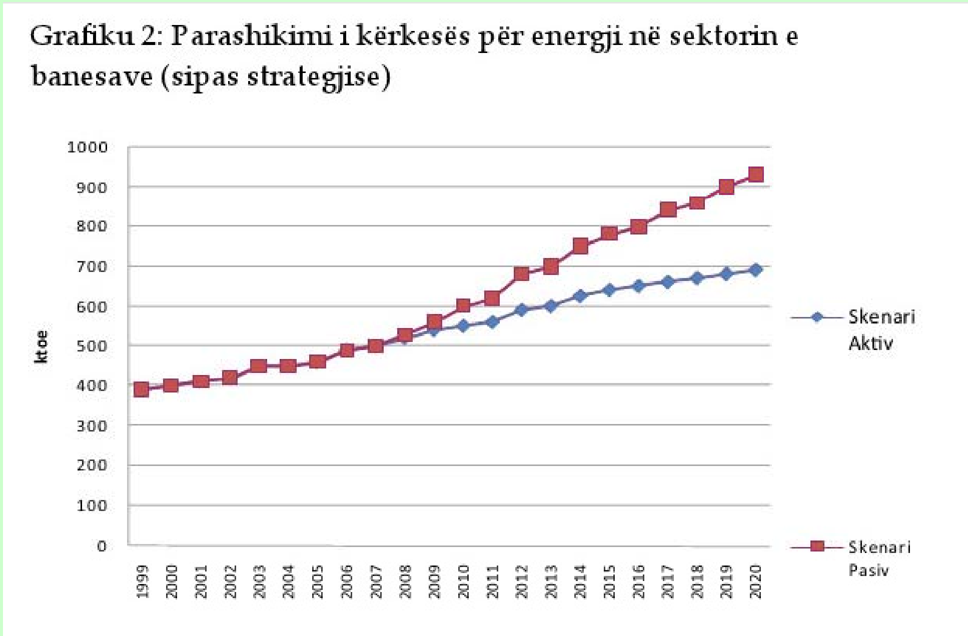
Energjia mesatare pa ngrohjen, 4400 GWh



ORE

Kurba e vazhdueshmerise vjetore te ngarkeses elektrike pa ngrohje me ngrohjen per vitin 1999 (Energjia elektrike totale e furnizuar 5775 GWh)





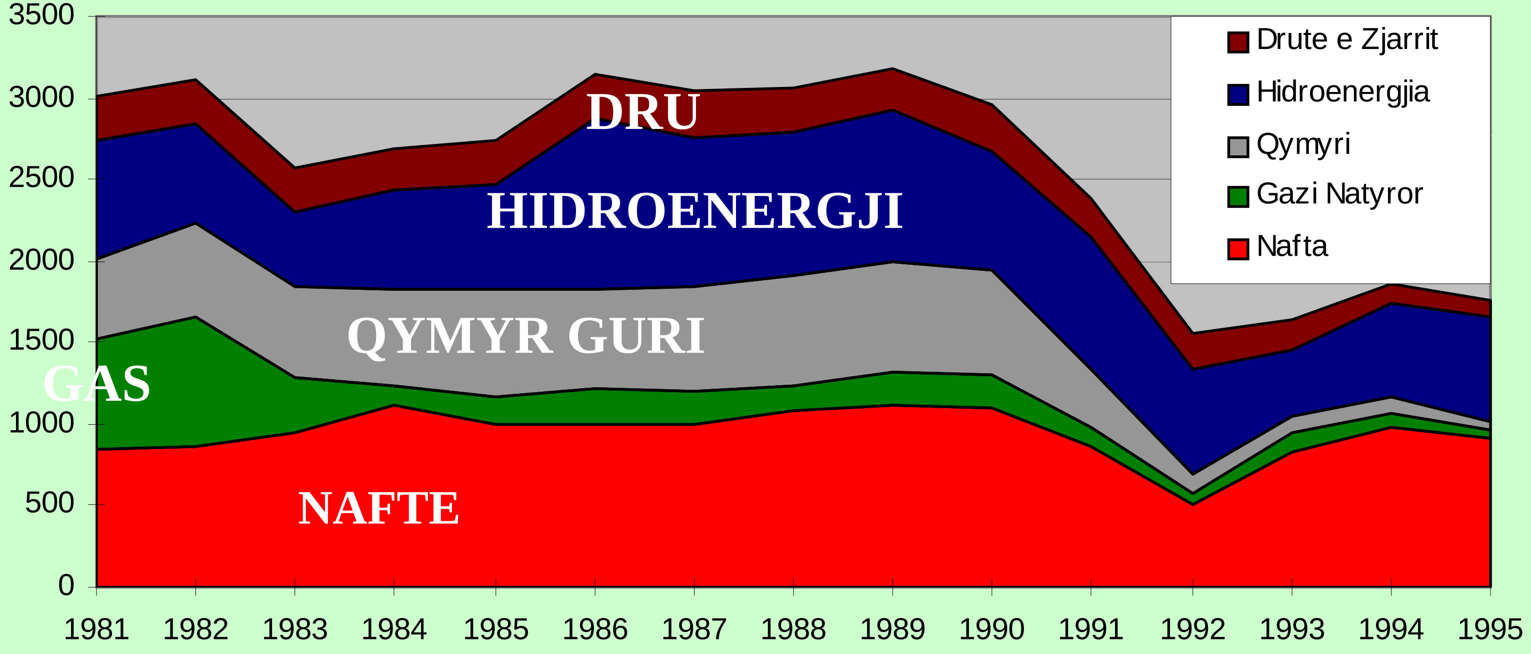
Nga 2000 ne 2033 konsumi energjise per ngrohje u rrit ne masen 15%

Ne 2020 rretet 111% kerkesa energjetike per ngrohjen/freskimin e godinave dhe uje te ngrohte ngaj 2003.

Sipas Strategjise Kombetare te Energjise , AKBN, 1999 dhe 2007

Konsumohen [971] për ngrohje sasi të mëdha dru zjarri, kjo lëndë defiçitare dhe me shumë vlerë (Agencia Kombetare e Energjise).

Çështja bëhet akoma më problemore me përdorimin e naftës e gazit për ngrohje, të cilat veç të tjerash emetojnë në atmosferë sasi të mëdha gazi CO_2.



Jane faktoret vendimtare qe bejne apel per ndergjegjesim per te kontribuar per gjetjen e zgjidhjeve optimale per kaperximin e kesaj situate kritike energjetike.

DIRECTIVAT E EGEC

Bashkimi Evropian (BE), për të përballuar sfidat e mëdha energjetike me të cilat që përballet, ka vendosur një politikë ambicioze energjetike, e cila mbulon gamën e plotë të burimeve të energjisë nga karburantet fosile, tek energjia bërthamore dhe burimet e rinovueshme (diellore, era, biomasa, **gjeotermale**, hidro-elektrike dhe të baticës), në një përpjekje për të nxitur një revolucion të ri industrial, i cili do të japë një ekonomi të lirë të energjisë, ndërkohë duke e bërë më të sigurtë, më konkuruese dhe më të qëndrueshme energjinë që konsumojnë [1, 2, 3].

- Në nenin 2 të Direktivës 2009/28/EC kërkohet përparimi në përdorimin e energjive nga burimet e rinovueshme. Paneli për ngrohjen dhe freskimin e rinovueshëm i Platformës (RHC)- i drejtuar nga European Geothermal Energy Council (EGEC), i mbledhur në 15 prill 2009 formuloi vizionin për vitin 2030 për sektorin e ngrohjes dhe freskimit gjeotermal. Sipas këtij vizioni, prezantohet skenari i kontributit drejt 100% të ngrohjes dhe freskimit me energji të rinovueshme në Europë. Platforma Europiane e Teknologjisë për ngrohjen dhe freskimin e rinovueshëm parashtron interesimin për energjitë e rinovueshme: biomasës, gjeotermale dhe diellore termale.

ENERGJIA GJEOTERMALE

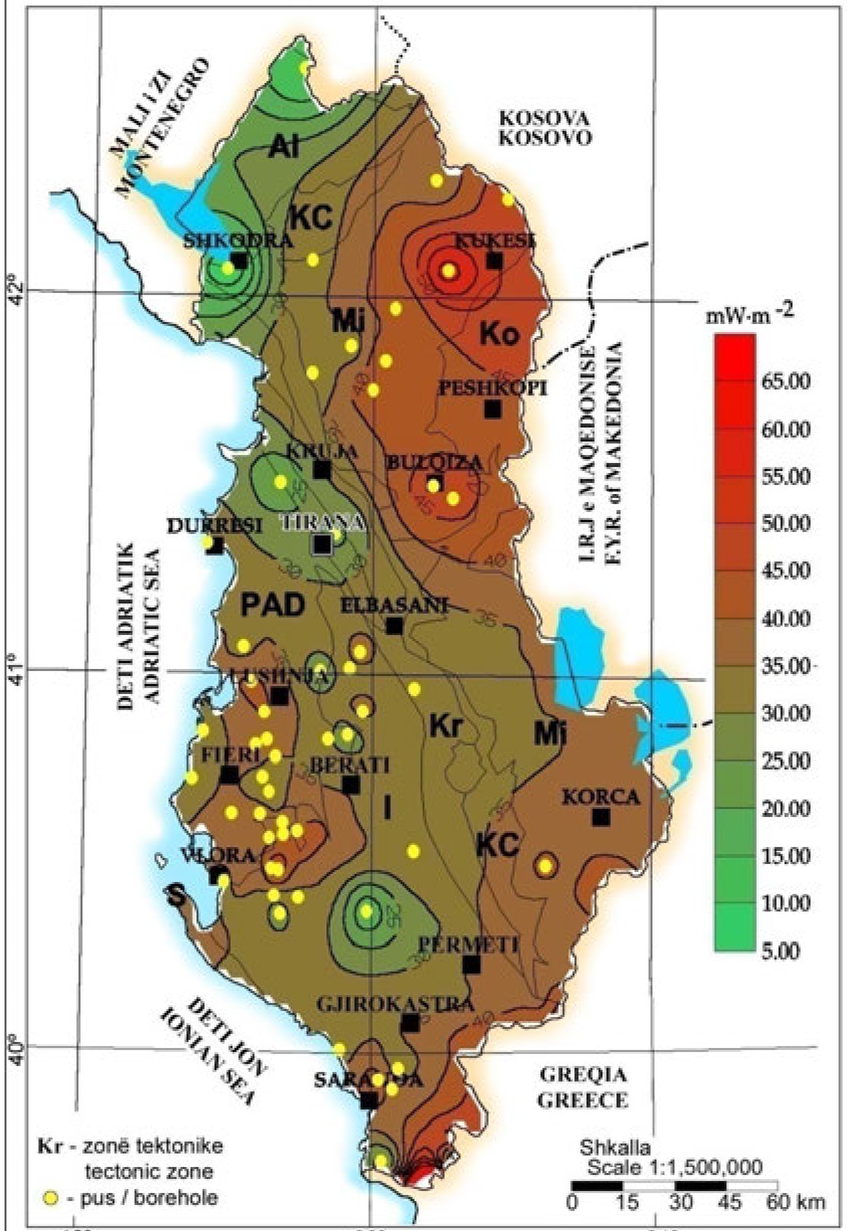
Nxehtesia qe jep Planeti i yne Toka eshte

Energji e rinovueshme- miqesore me mjedisin.

Situata e Energjise Gjeotermale e entalpise se ulet ne Shqiperi ofron dy drejtime te perdorimit te drejtperdrejte te saj:

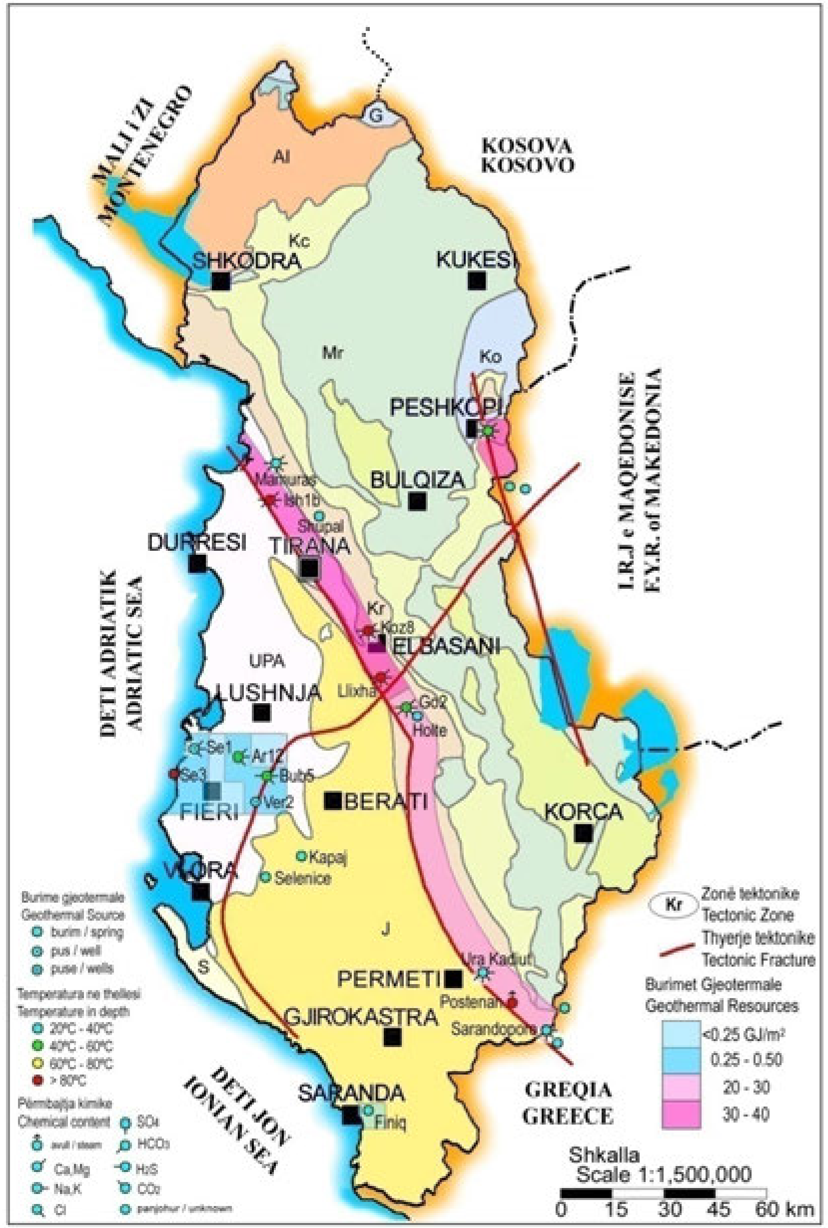
1. Ngrohja dhe freskimi i godinave

2. Shfrytezimi kompleks dhe kaskade i energjise se ujerave termale



Harta e dëndësisë së fluksit të nxehtësisë
Heat Flow Density Map

Fleta / Plate 16



Harta tematike gjeotermale
Geothermal Thematic Map

Fleta / Plate 17

Zakonisht, njerezit identifikojne

Ujerat e burimeve gjeotermale= *Energjine Gjeotermale*

kjo eshte pjeserisht e vertete.

Per me teper, burimet gjeotermale jane dukuri relativisht e rralle.

Fluksi i nxehtesise eshte energjia e rinovueshme gjeotermale,

te cilen Planeti i yne TOKA na e ofron kudo

- Kete pasuri, mund ta marrim kurdohere, kudo, duke perdorur teknologji te pershtatshme.

Ne kete referat do tu paraqesim mundesite me te rendesishme per shfrytezimin e saj ne Shqiperi.

Regjimi gjeotermal i Shqipërisë na lejoi të rekomandojmë që edhe në Shqipëri është e mundur teknikisht dhe ekonomikisht të fillojë ndërtimi i ***sistemeve moderne Këmbyes Nxehtësie-Pus-Pompë Gjeotermale Nxehtësie***, të cilët janë sistemet me efektivitet ekonomik të lartë dhe më kursimtaret në energji. Në vendet e përparuara, me rritëm të madh po shtohet numri i këtyre instalimeve.

Sot numurohen mbi 570 000 instalime në vende të ndryshme, duke ngrohur dhe freskuar shtëpi me sipërfaqe 100 m^2 e deri në blloqe të mëdha godinash me sipërfaqe të përgjithëshme deri 161 650 m^2.

Ekzistojne dy tipe burimesh nxehtesie te Tokes

1. Nxehtesia e truallit dhe
2. Nxehtesia e baseneve te ujerave nentokesore.

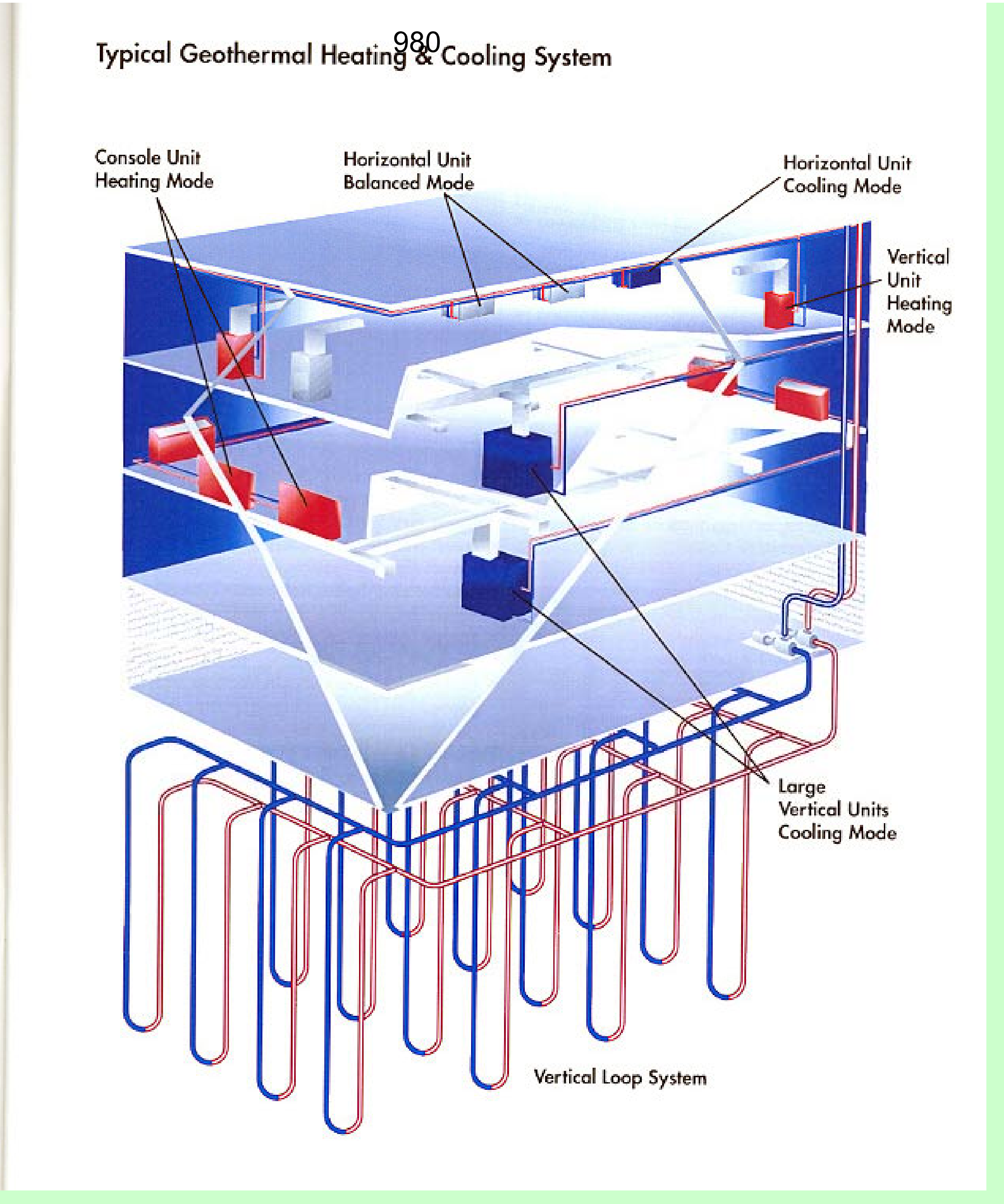
Ne varesi te tyre, zbatohen dy teknologji per shfrytezimin e kesaj energjie (Lund J. W. 1996, Rybach L. et al. 2000):

Se pari, *Sistemi i mbyllur*: Pus-kembyes vertikal nxehtesie-pompe gjeotermale nxehtesie (Fig. 3),

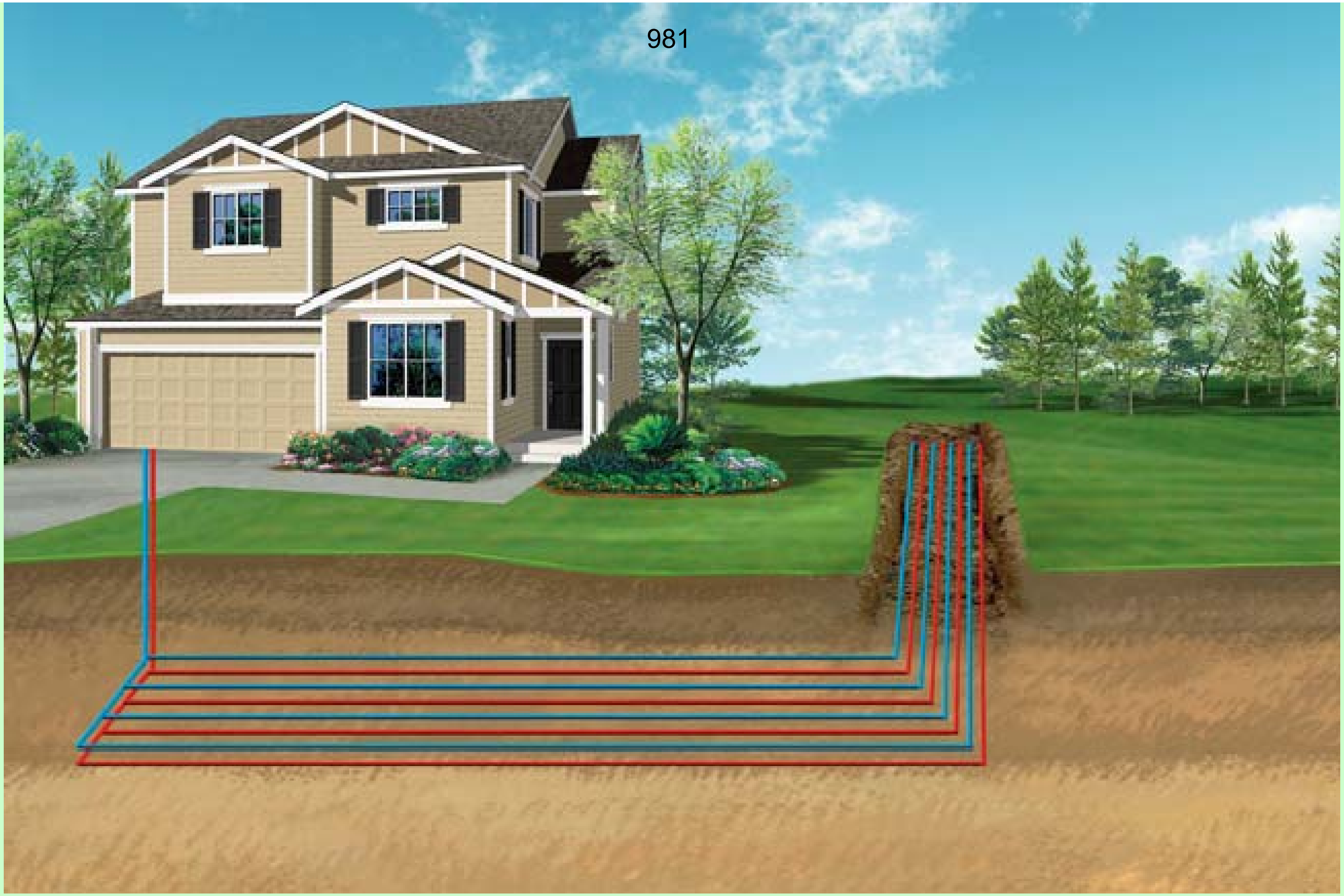
Se dyti: *Sistemi i hapur*: Uji nentokesor – pompe gjeotermale nxehtesie.

SISTEMI NGROHES

PUS-KEMBYES VERTIKAL NXEHTESIE- POMPE GJEOTERMALE NXEHTESIE



SISTEMI I BATERISE SE PUSEVE

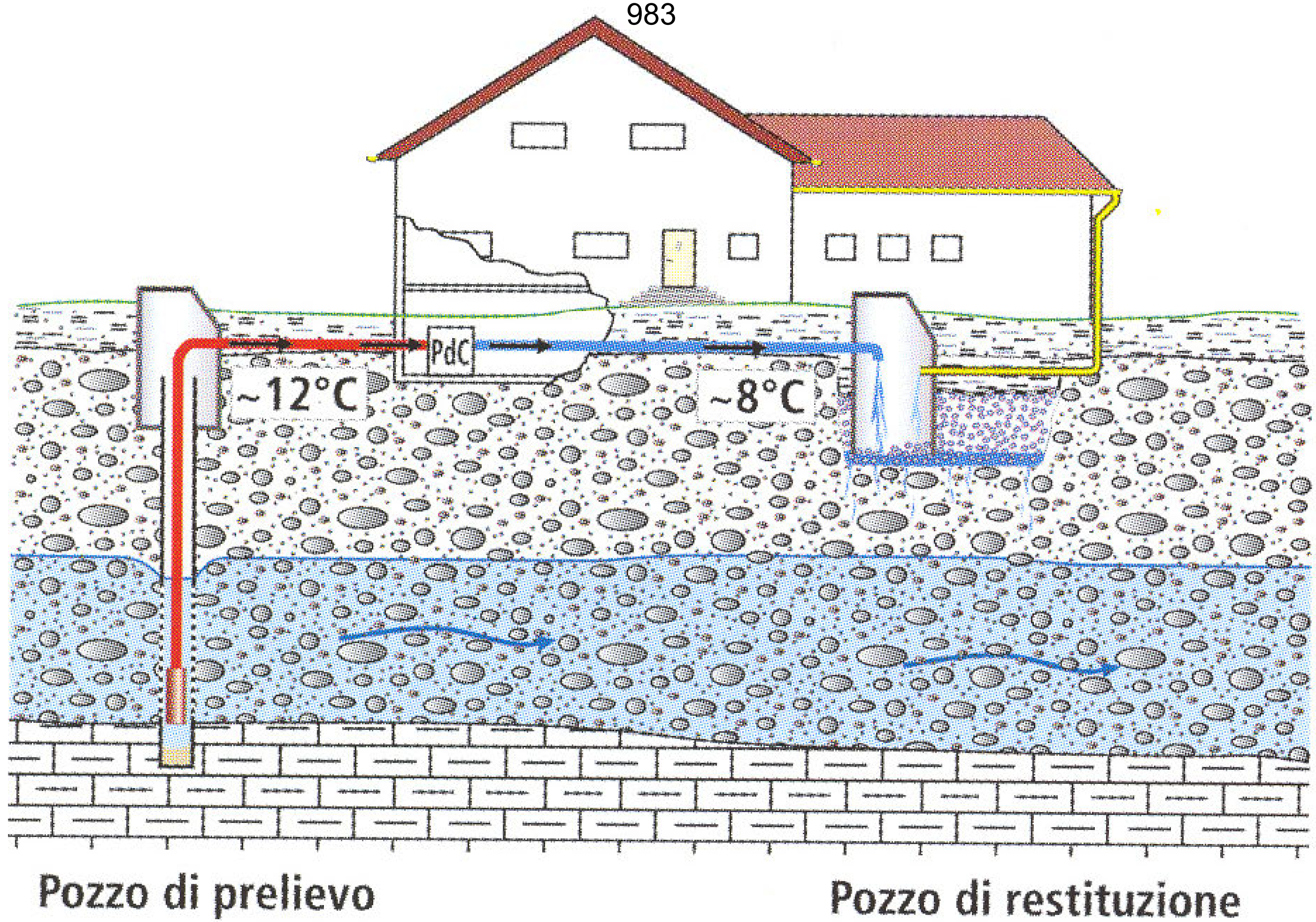


SISTEMI NGROHES

PUS-KEMBYES HORIZONTAL NXEHTESIE-

POMPE GJEOTERMALE NXEHTESIE

BURIMI I NXEHTESISE: UJI I LIQENIT



BURIMI I NXEHTESISE: HORIZONTI NENTOKESOR UJEMBAJTES

Aktualisht këto janë sistemet më moderne, me efektivitetin ekonomik më të lartë dhe konsumin më të vogël të energjisë elektrike, me teknologji më të përparuar miqësore me mjedisin dhe po bëhen gjithënjë e më shumë më popullore.

Në 26 shtete në Europë dhe në SHBA janë montuar:

570 000 mijë instalime BHE-HP, më fuqi 12 KW sejcila, për ngrohjen dhe freskimin e shtëpive-vila,

Mijëra instalime më fuqi deri 500-1500 KW për ngrohjen e institucioneve dhe të blloqeve të banesave komunale.

Në 26 shtete në Europë dhe në SHBA, gjate vitit 2005 janë montuar 900 mijë instalime kembyes vertikal nxehtësie- Pompë gjeotermale nxehtësie, më fuqi 12 kW sejcila, për ngrohjen dhe freskimin e shtëpive-vila, por ka edhe mijëra instalime më fuqi deri 500-1500 kW për ngrohjen e institucioneve dhe të blloqeve të banesave komunale.

Kapaciteti i instaluar eshte 15 723 MWt dhe energjia e shfrytezuar 24 200 GWh.

Ne Gjermani aktualisht ka mbi 40 mije instalime. Ne vitin 2005 jane instaluar:

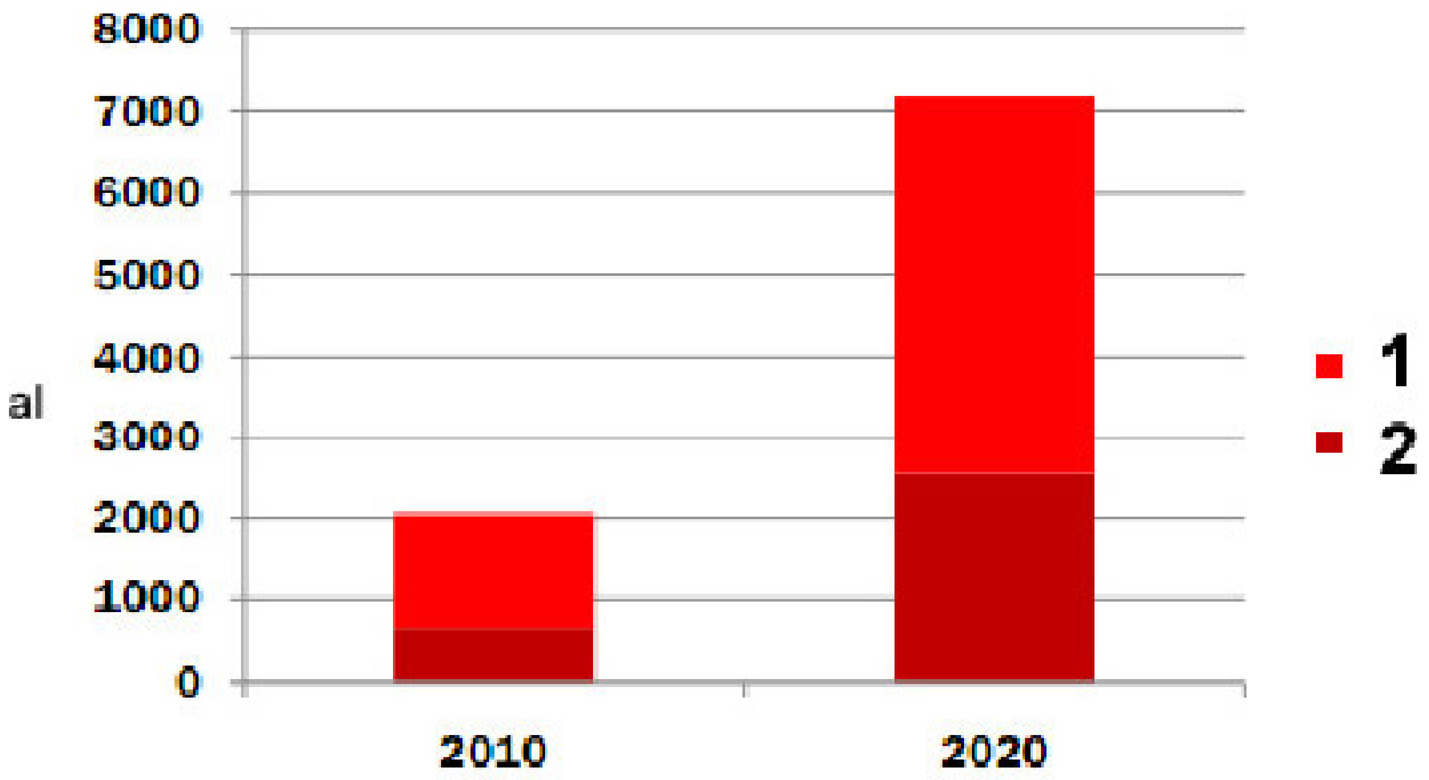
6799 pompa gjeotermale nxehtesie dhe vetem

1526 kondicionere me pompa ajer-ajer.

. . .

Rritja e kërkesave për ngrohje gjeotermale për periudhën 2010-2020

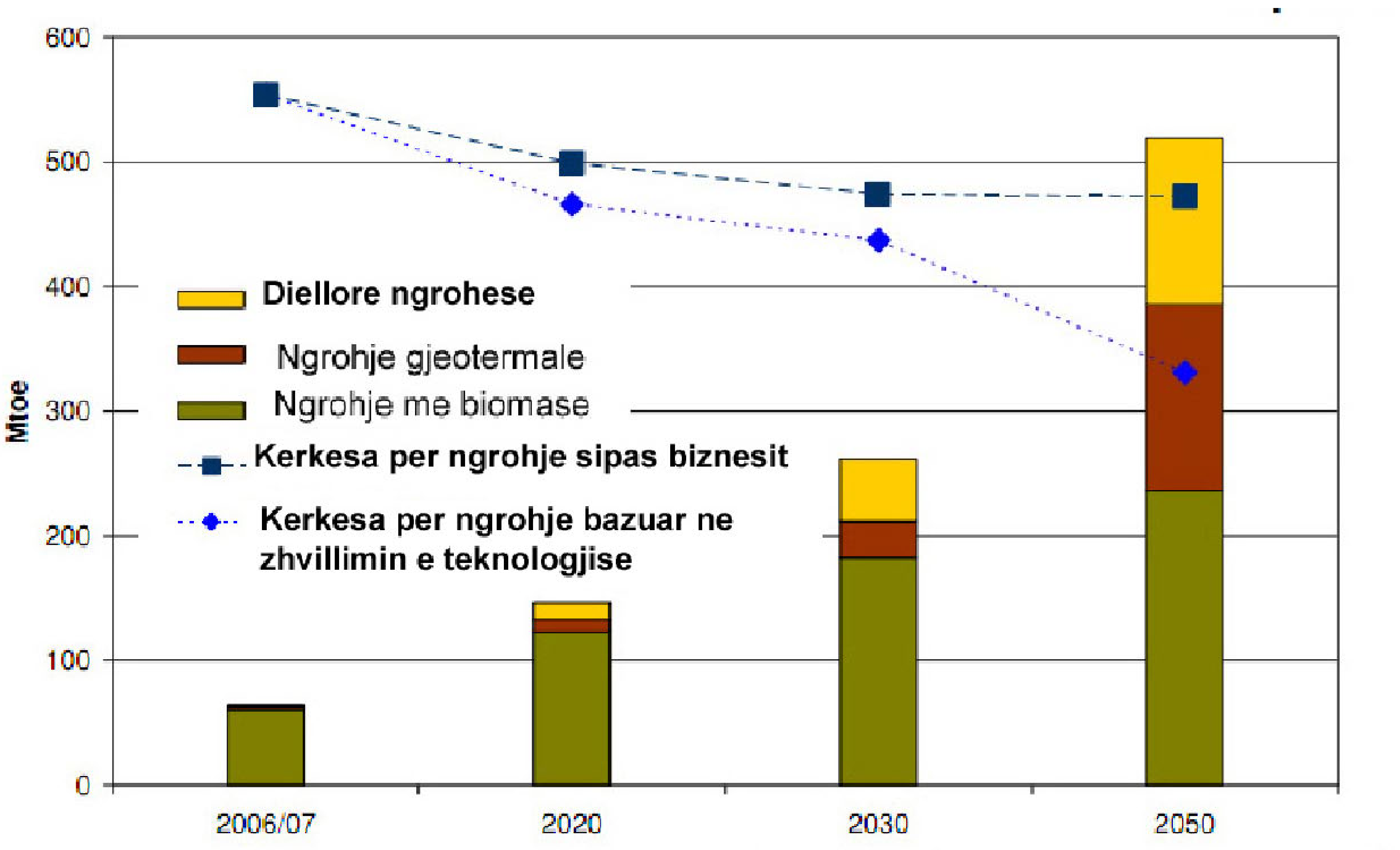
(Sipas EUROFERES, 2011).



1- Gjeotermale me pompa nxehtësie;
2- Gjeotermale me ujëra te nxehtë.

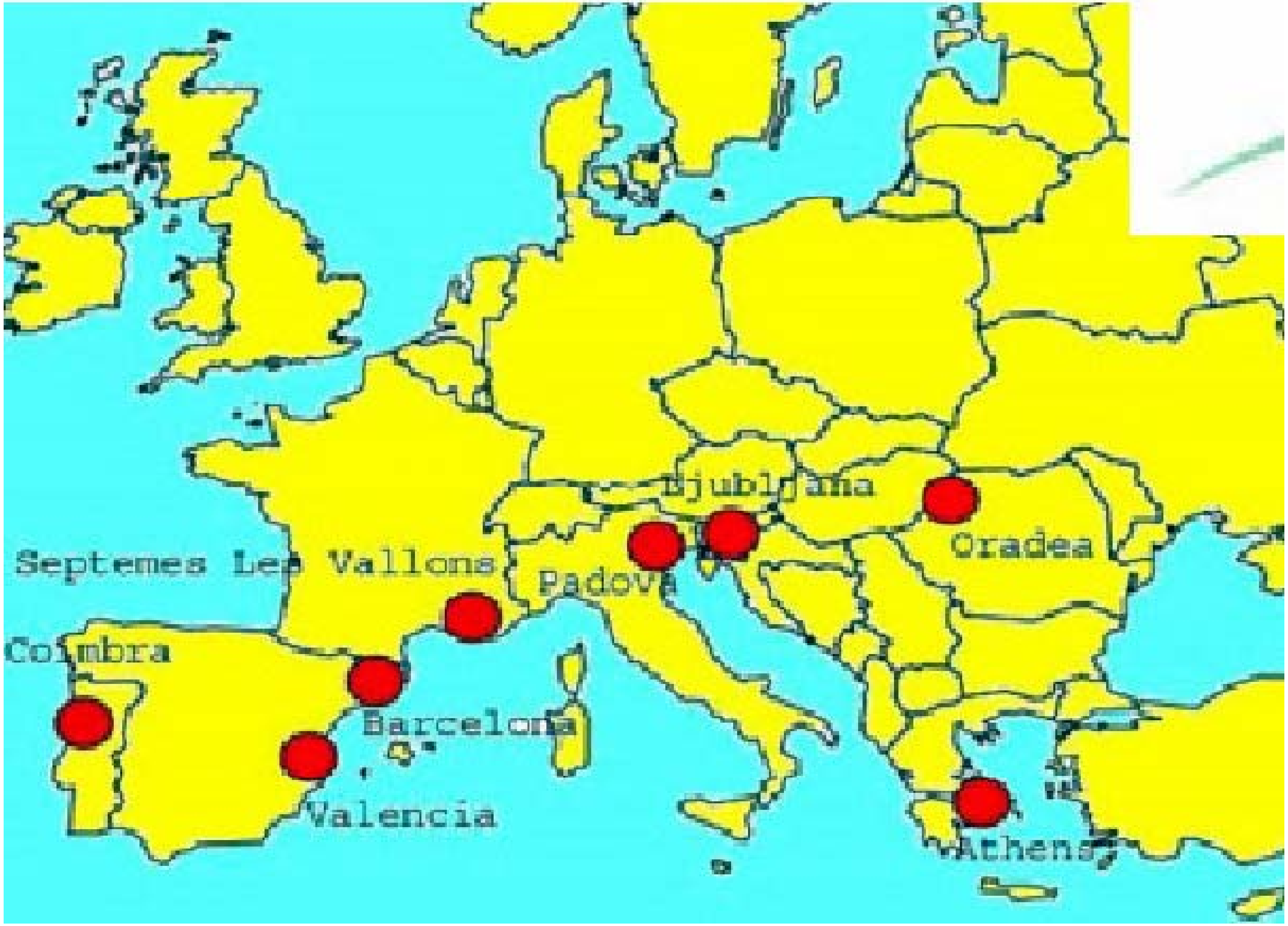
Skenari i rritjes së kërkësave për shfrytëzimin e energjisë gjeotermale dhe të biomasës për ngrohje.

(Sipas Sanner B. 2.11)



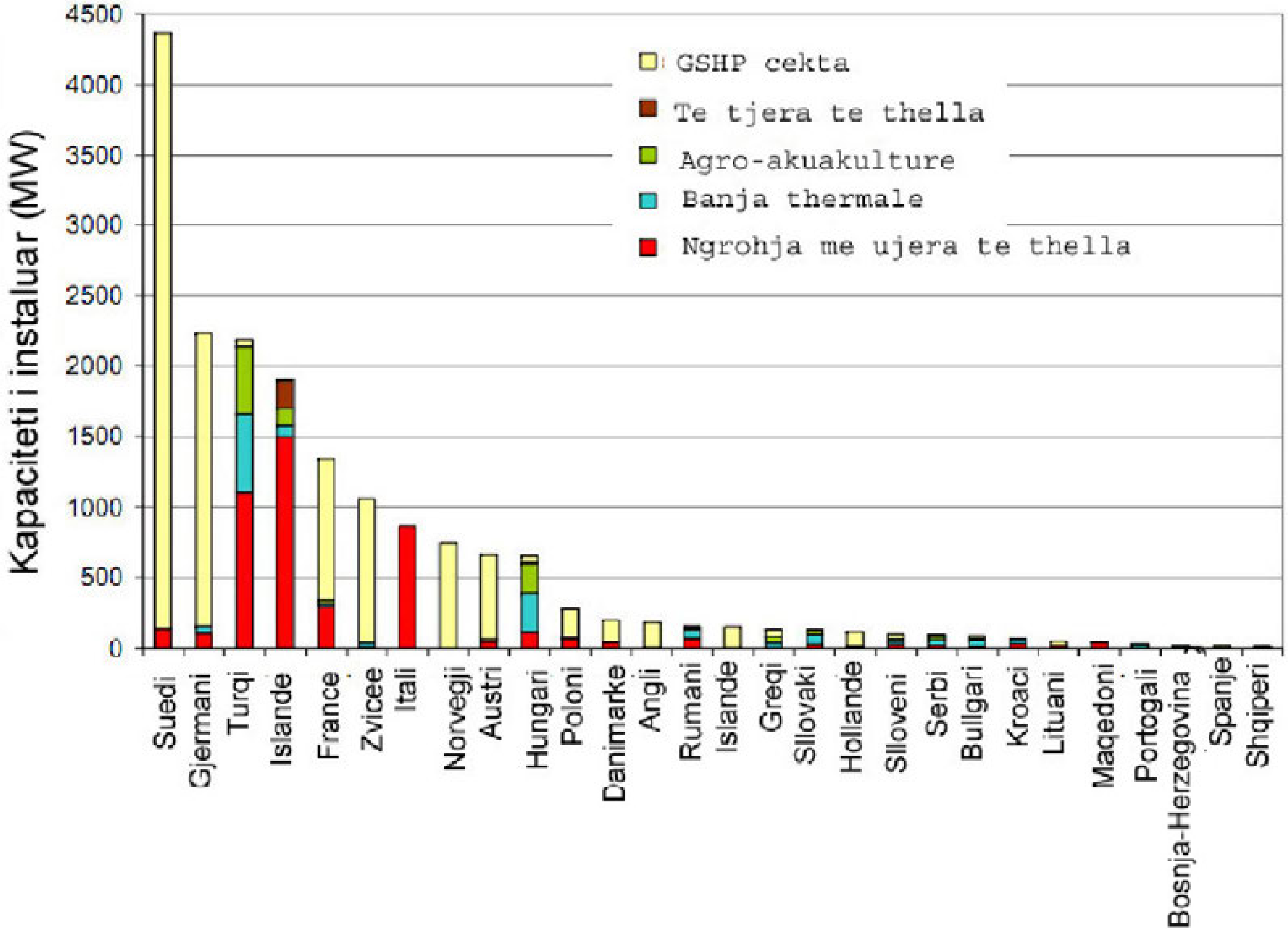
Prirja e shtrirjes së përdorimit të sistemeve gjeotermale të ngrohjes/freskimit të godinave në vendet Mesdhetare.

(Sipas Sanner B. 2011)



Kapaciteti i instaluar për shfrytëzimin e energjisë gjeotermale në vende të ndryshme

(Sanner B. 2011)



Shembull tipik është edhe Zvicra, ku ka 30 000 instalime , me fuqi të pompës nga 19-40 KW, të cilët shfrytëzojnë nxehtësinë e shtresave pranësipër-faqësore të tokës me temperaturë 10^{o}C.

3500 instalime kishte ne vitin 1995,

27 000 arriten ne 2002.

Prodhimi i energjisë me këto sisteme:

70 GWh, në vitin 1980

365 GWh, në vitin 1999

- ne Austri ka 23 000 instalime,
- ne Suedi 200 000,
- ne Danimarke 43 000,
- ne France 40 000,
- ne USA 600 000.

Në Japoni, (Gazeta Japan Times, Jan. 21, 2003), duke perdorur energjenine gjeotermale te shtresave pranesiperfaqesore projektohet kursimi i energjisë deri 40%. Shpenzimet për këtë realizimin e këtij projekti do të vëtëshkyhen brënda 10 vjetëve.. Dy të tretat e kostos së ndërtimit, që vlerësohet në 10 milion yen për çdo instalim, do të mbështetet nga qeveria dhe autoritetet lokale.

Shembuj tipikë për ngrohjen dhe freskimin e të godinave publike ose të banimit të mëdha me anen e sistemit Pus-Këmbyes Nxehtësie-Pompë Gjeotermale Nxehtësie në disa shtete:

GREQI:

1. Godina THENAMARIS SHIPS MANAGEMENT Inc. në Athinë: Sipërfaqe 4 500 m²

· Instaluar dy njësi të Pompave gjeotermale të nxehtësise:

Kapaciteti ngrohës 250 kW

Kapaciteti i freskimit 278 kW

· Debiti ujor për të dy pompat

13.9 l/sek nga një pus i cekët

Koeficienti i Performancës:

4.37 për ngrohje ,

1.76 për freskim

Photo 3. THENAMARIS Ships Management Inc. building, Athens, Greece where is sucsessfully worked Borehole-Heat Exchanger-Geothermal Heat pump System for space heating and cooling

Photo. 4. Geothermal Heat Pumps installed in the THENAMARIS building

Sistemi ka karakteristika ekonomike që paraqiten në pasqyrën e më poshtme:

Energjia termale e dhënë nga sistemi gjatë një muaji, në kW	Energjia elektrike e konsumuar gjatë muajit për të vënë në punë sistemin, në kW	Koeficienti i Performances i sistemit	Energjia elektrike specifike e konsumuar për sistemin, në Wh/m^2
Ngrohje Janar, 2003			
186 000	42 560	4.37	12.7
Freskim Qershor, 2003			
200 160	112 600	1.76	34.7

2. Bashkia e Pylays, Selanik.

Tre godina me sipërfaqe të përgjithëshme 2500 m^2, volumi 7500 m^3

- Burimi i nxehtësisë:

  21 puse, sipas matrices 4.5x4.5 m,

  me thellësi 80m,

  sasia totale e metrazhit të shpimit 1680 m,.

- Këmbyesi vertikal i nxehtësisë: Gjatësia specifike 6.34 m/kW, tub plastmasi.
- Sistemi ngrohës: 11 pompa gjeotermale nxehtësie ujë-ujë,me fuqi të përgjithëshme:

  265.4 kW për ngrohje dhe

  280.1 kW për freskim.

- Koha e punës së sistemit: 5 ditë në javë, 7 orë në ditë.

.

Vlerësime ekonomike. Sistemi gjeotermal është më efektiv sesa sistemet e tjera në masën:

- *Për ngrohje*: 74% ndaj kaldajës me naftë

  24% ndaj kondicionerëve ajër/ajër

-

Për freskim: 46% ndaj kaldajës me naftë

18% ndaj kondicionerëve ajër/ajër

Godinat e Bashkisë Pylays, Selanik dhe salla e pompave gjeotermale

MALI I ZI.

Sistemi ngrohes i intergruar- energji gjeotermale dhe energji diellore ne Sllovenska Plaza, Budva

FRANCE

Godinë puiblike në Lion:

- Sipërfaqja e godinës 16.633 m^2.
- Energjiia vjetore e përftuar 2 108 114 kWh/vit.
- Energjiia vjetore e konsumuar 490 259 kWh/vit.
- Koeficienti i performancës COP = 4.75
- Kosto vjetore e energjisë 33 365 Euro/vit për gjithe sipërfaqen e ngrohur.
- Kosto e energjisë 2 E/(vit.m^2).
- Vetë shlyerja e investimit 3 vjet.

Godinë publike në Lion, Francë, e ngrohur me sistemin gjeotermal

HOLLANDE

Bllok banesash banimi në qytetitn Sëfterband:

- Sipërfaqja e ngrohur:

  79 apartamente x 100 m^2 = 7 900 m^2

- Energjia vjetore e përftuar

  33 000 kWh/vit,

- Energjia vjetore e konsumuar

  15 000 kWh/vit,

- Koeficienti i performancës

  COP = 2.

GJERMANI:

Sisteme gjeotermale ngrohëse dhe freskuese shumë të mëdha

Tipike midis tyre është ansambli i godinave të German Air Traffic Control headquarters në Langen, në jug të aeroportit të Frankfurtit

- Volumi total i godinave 230.000 m^3
- Sipërfaqja e godinave 57.800 m^2
- Sistemi ngrohës: shtresat pranësipërfaqsore të tokës
- Këmbyesit verikal të nxehtësisë janë vendosur në dy fusha baterish pusesh:

  154 puse, sejcili 70 m i thellë,

  sipas matrices 5 x 5 m.

-

Pamje e ansamblit të godinave të German Air Traffic Control, Frankfurt

Fig. 13: Artist´s view of DFS headquarter, Langen (from Seidinger et al., 2000)

Vendosja e dy fushave të baterive puseve në German Air Traffic Control, Frankfurt.

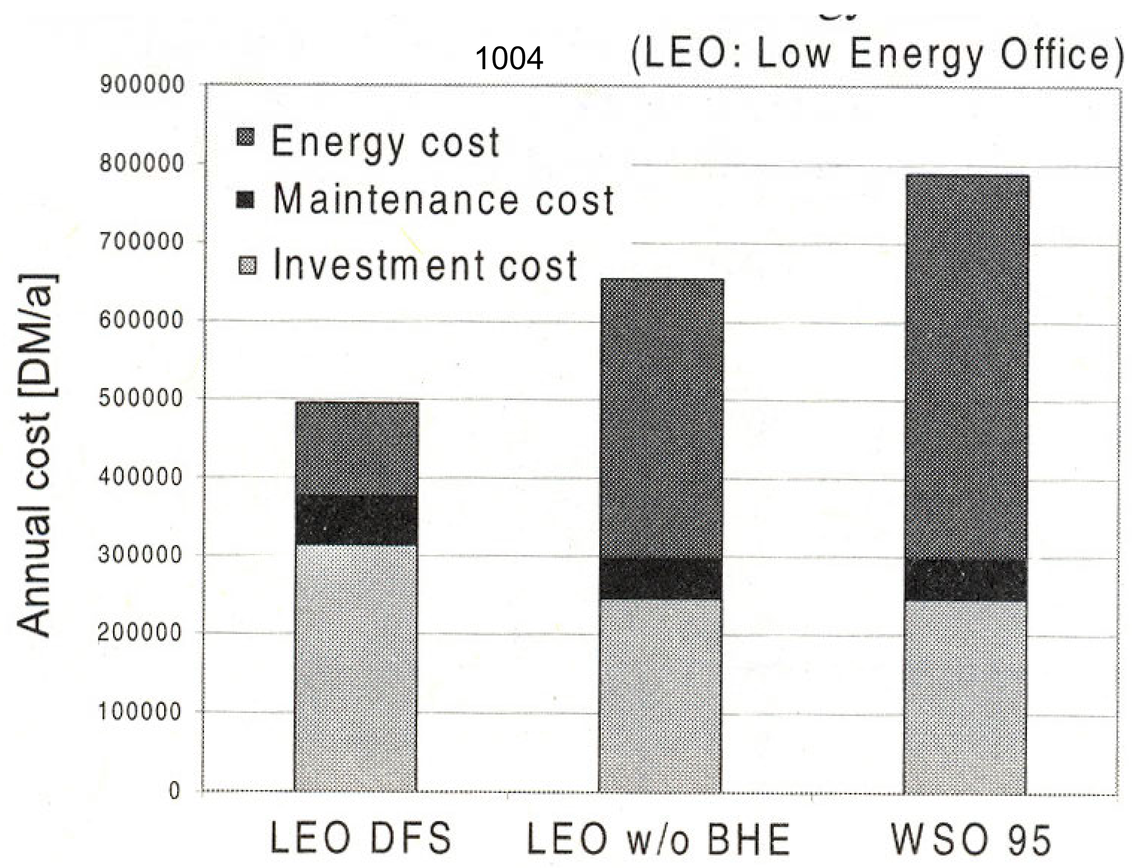
Kapaciteti total ngrohës dhe freskues i të dy fushave, përkatësisht 330 kW dhe 340 kW.

.

Sistemi gjeotermal redukton në masën 35% konsumin e energjisë krahasur me sistemet konvencionalë të ngrohjes dhe freskimit.

.

Reduktimi i kostos: 300.000 DM/vit.



Krahasimi i kostos vjetore për ngrohjen dhe freskimin e German Air Traffic Control.

Sistemi LEO DFS: Këmbyes vertical nxehtesie (BHE), pompë nxehtësie, rrjet local ngrohje, chiller.

Sistemi LEO pa BHE: Rrjet local ngrohje, chiller.

Sistemi WSO 95: Rrjet local ngrohje, chiller.

2) FAAG Godina “Living and Working at Baseler Platz” ne Franksfurt-Main Foto 8).

Sistemi ngrohes: pus-pompe gjeotermale nxehtesie.

Fig. 17: Architectural simulation of the FAAG-building “Living and Working at Baseler Platz” in Frankfurt/Main

Godinat Steve Garrett, Oklahoma.

Po ne Shqiperi?

- Aplikimi i pare eshte ngrohja e shkolles profesionale ne Erseke

Aplikimi me madhor eshte sistemi ngrohes/freskues i kullave binjake ne Bulevardin Deshmoret e Kombit, Tirane

….

- Siperfaqja e te dy kullave 18.000 m2
- Fuqia e prgjitheshme te sistemit ngrohes 1.200 kW
- Sistemin ngrohes te tyre perbehet ng dhjetra pompa nxehtsie uje-uje me fuqi 12 dhe 24 Kw

Projektuar nga Dr. Inxh. Ramadan Alushaj dhe firma

Profesion-KLIMA, Tirane.

VLERESIM EKONOMIK I SISTEMIT

Konsumi energjise elektrike ose karburantit per venien ne pune te sistemt ngrohes freskues:

- *Energji elektrike* (COP=3,5) 343 kW/h 40 E/h
- *Nafte* 120 l/h 146 E/h

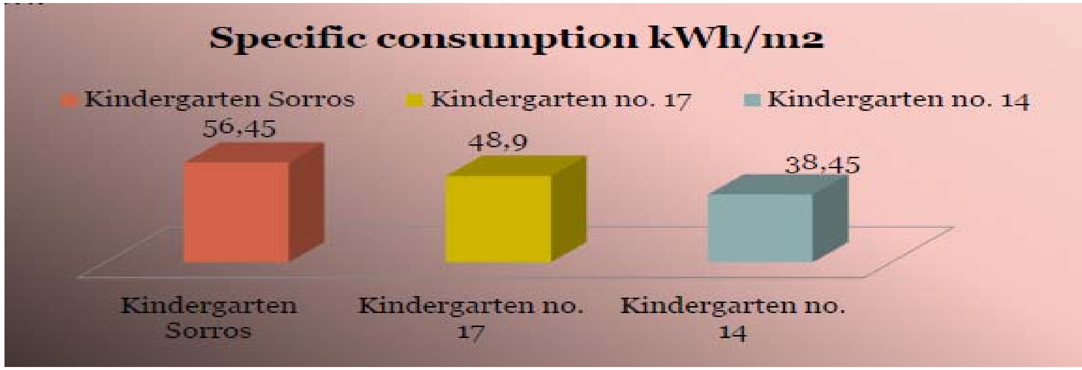
Shkolla e Mesme “Peter Mahringer”, për teknologji informazioni, pranë Kuvendit Franceskan, Shkodër

Shkolla ka godinë rekatëshe, projektuar nga Design Studio Vera, Architect&Co, Tiranë. Në skemën ngrohëse/freskuese janë vendosur dy chillera, secili 90 kW**.**

Uji nëntokësor nga pusi kalon nëpër një këmbyes nxehtësie, me prurje 38 m^3/h (10.55 l/sek).

Efekti ekonomik i sistemit gjeotermal në Kopshtin e fëmijëve Nr. 14, Korçë

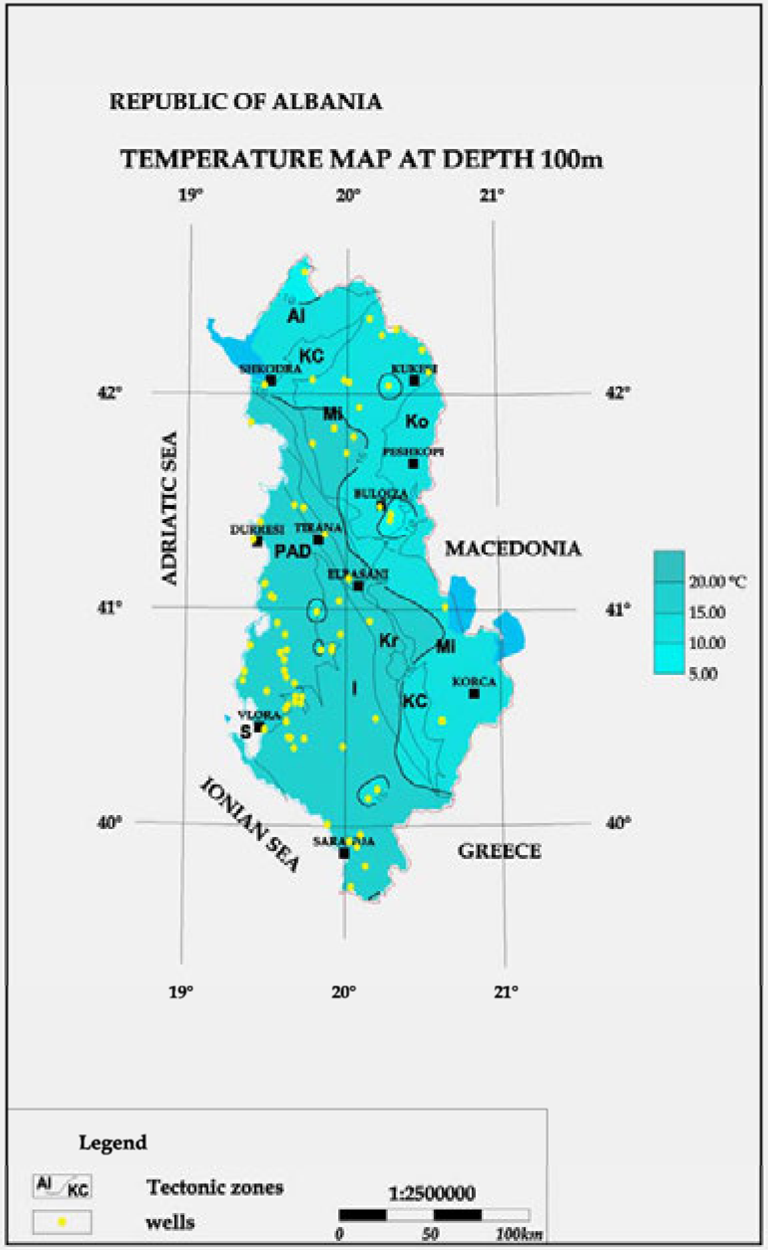
•



TË DHËNA PËR ZONËN E TIRANES

Ashtu si kudo, edhe në Shqipëri shtresat pranësipërfaqesore të Tokës kanë nxehtësi, e cila mund të shfrytëzohet me sukses për ngrohjen e godinave publike (zyra, spitale, bibioteka, shkolla, teatro e kinema, godina aeroporti etj) si edhe blloqe banesash e vila për banim, duke shfrytëzuar sistemet moderne të ngrohjes:

Këmbyes Nxehtësie-Pus-Pompë Gjeotermale Nxehtësie.



Bregdetare

Temperatura minimale 16.60 ºC

Temperatura maksimale 18.80 º

Temperatura mesatare 17.80 ºC

Fushore perëndimore

Temperatura minimale 17.15 ºC

Temperatura maksimale 18.41 º

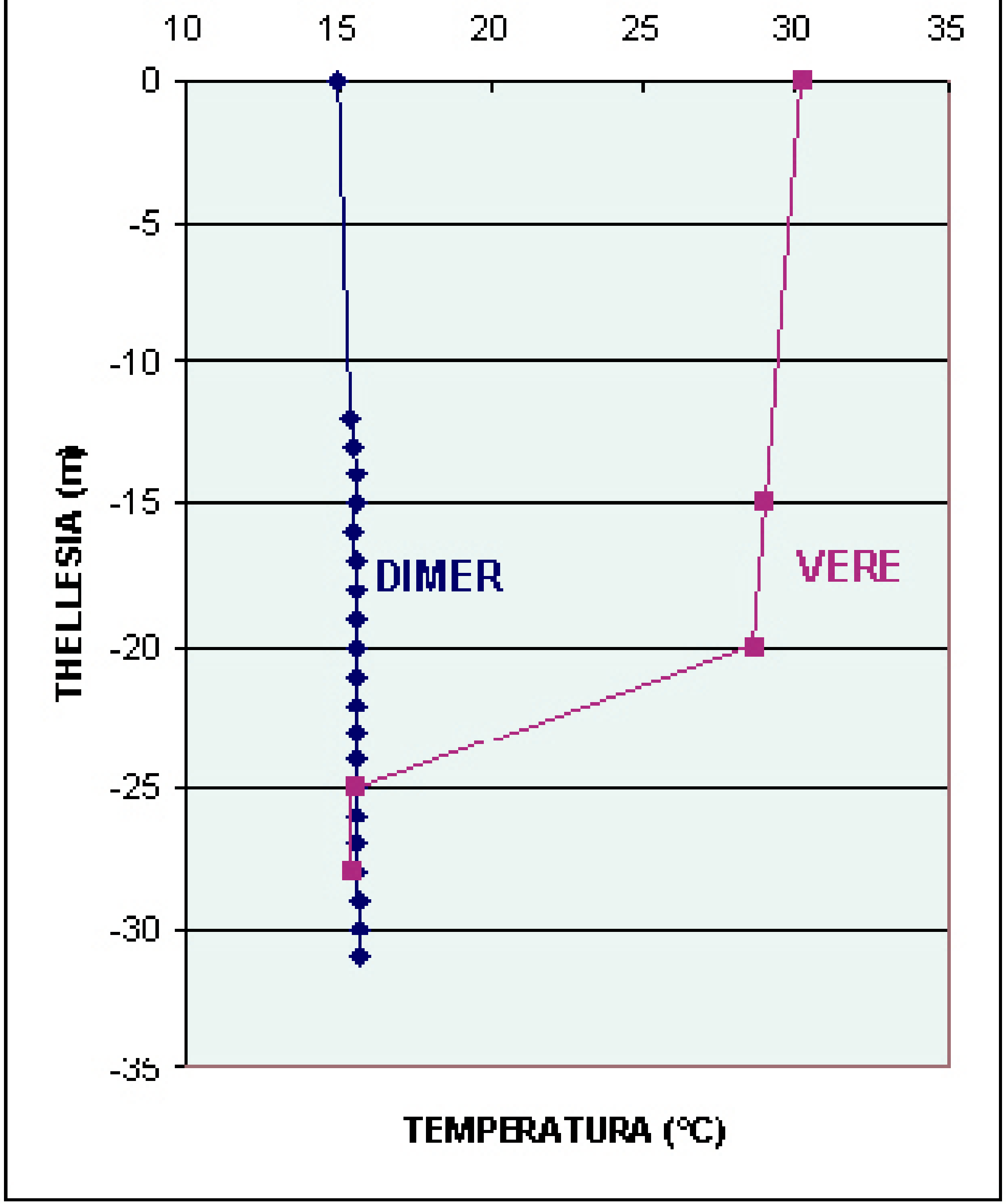
Temperatura mesatare 18.0 ºC

Kodrinore- malore

Temperatura minimale 6.70 ºC

Temperatura maksimale 18.60 º

Temperatura mesatare 14.75 ºC



Termograma e nje pusi ne Rinas, Tirane. Deri ne thellesine 20 m verehet ndikimi i rrezatimit te diellit.

Nen kete thellesi temperatura mbetet

e pandryshuar ne stine te ndryshme

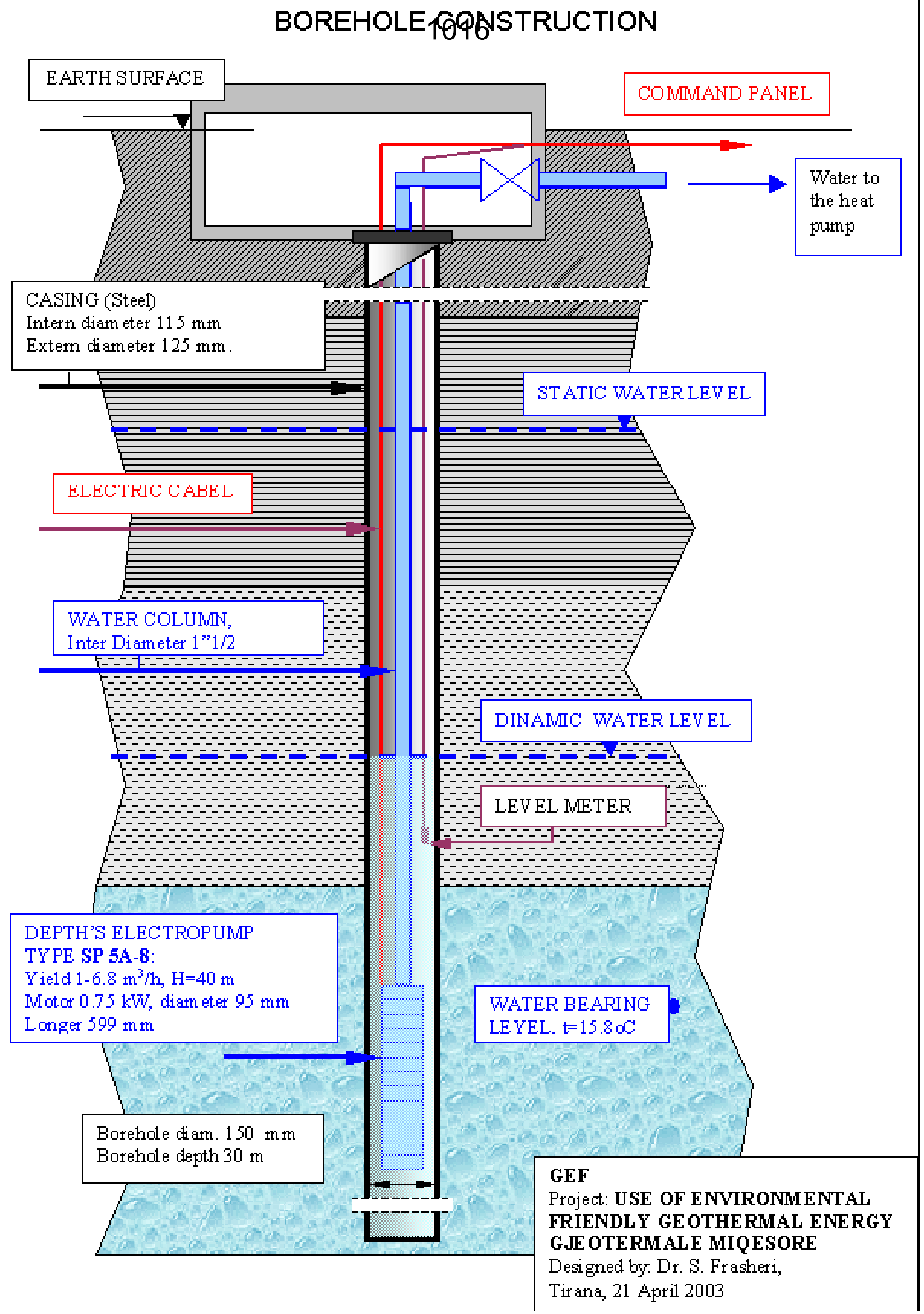
Nga analiza e gjendjes së regjimit gjeotermal të prerjes pranësipërfaqësore është e niveleve të tilla që lejon të shfrytëzohet nxehtësia e tyre për të ngrohur godinat, duke përdorur sistemet moderne Këmbyes Nxehtësie Pus - Pompë Gjeotermale Nxehtësie.

Nxehtësia e këtyre shtresave ka shkaktuar edhe ngrohjen e ujërave të truallit në rezervuarin nëntokësor.

Temperatura e ujit te shtreses zhavorrore eshte 14-15 oC,

Temperatura e ujit te shtresave ranore te kuaternarit t=15-16oC

– ***Ketej konkludohet se uji i pellgut të qytetit të Tiranës mund të shërbejë si burim nxehtësie për pompat gjeotermale të nxehtësisë, pasi është ngrohur nga shtresat e tokës.***


BOREHOLE CONSTRUCTION
EARTH SURFACE
COMMAND PANEL
Water to the heat pump
CASING (Steel)
Intern diameter 115 mm
Extern diameter 125 mm.
STATIC WATER LEVEL
ELECTRIC CABEL
WATER COLUMN,
Inter Diameter 1"1/2
DINAMIC WATER LEVEL
LEVEL METER
DEPTH'S ELECTROPUMP
TYPE SP 5A-8:
Yield 1-6.8 m3/h, H=40 m
Motor 0.75 kW, diameter 95 mm
Longer 599 mm
WATER BEARING
LEYEL. t=15.8oC
Borehole diam. 150 mm
Borehole depth 30 m
GEF
Project: USE OF ENVIRONMENTAL FRIENDLY GEOTHERMAL ENERGY GJEOTERMALE MIQESORE
Designed by: Dr. S. Frasheri,
Tirana, 21 April 2003

ANALIZA E KOSTOS

Godina: Hotel

Sipërfaqja e përgjithëshme e 3 kateve: 610 m^2

Ngrohja: me kalorifere (radiatorë)

Kapaciteti për ngrohje 68.5 KW

Periudha e ngrohjes 1836 orë/vit

Sistemi ngrohës, analizohen tre variante:

a) Pus-pompë gjeotermale nxehtësie

b) Kaldaje me naftë

c) Kondicionerë ajër-ajër

Kosto e përgjithëshme paraprake e instalimit:

A Pus-pompë gjeotermale nxehtësie 43.000 Euro

b Pus-kemb. Vert. nxehtesie-pompe gjeo. nxeht. 68.461 Euro

c Kaldaje me naftë 27.000 Euro

d Kondicionerë, tip “General” 15.600 Euro

Kosto paraprake e instalimit për metër katror të sipërfaqes:

Pus-pompë gjeotermale nxehtësie 71,66 Euro/m^2

Pus-kemb. Vert. Nxeht.-pompe gjeo. nxeht. 112,63 Euro/m^2

Kaldaje me naftë 44,26 Euro/m^2

Kondicionerë ajër-ajër, tip “General” 26,00 Euro/m^2

Kosto paraprake vjetore operative e konsumit të energjisë elektrike ose lëndës djegëse gjatë 1836 orëve, për të vënë në punë sistemin ngrohës:

a) Pus-pompë gjeotermale nxehtësie 33.304 kW 3.384 Euro

a

B b)Pus-kem. V. nxeh.-pom. gjeo. nxe. 33.304 kW 3.384 Euro

c) Kaldajë me naftë 12.282 Lit. naft. 11.982 Euro

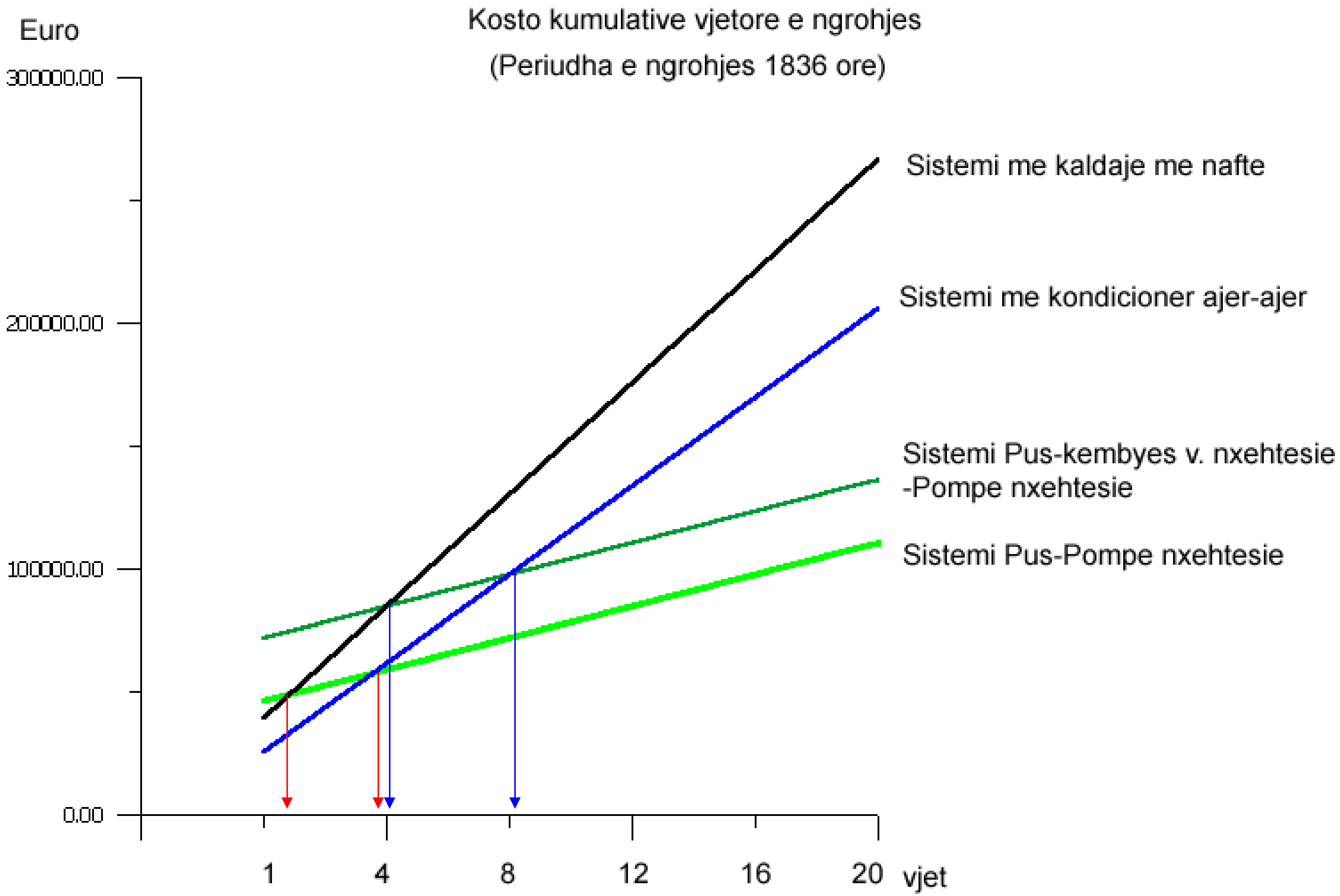
d) Kondicionerë 93.636 kW 9.515 Euro

e) Radiatorë elektrikë 137.700 kW 13.993 Euro

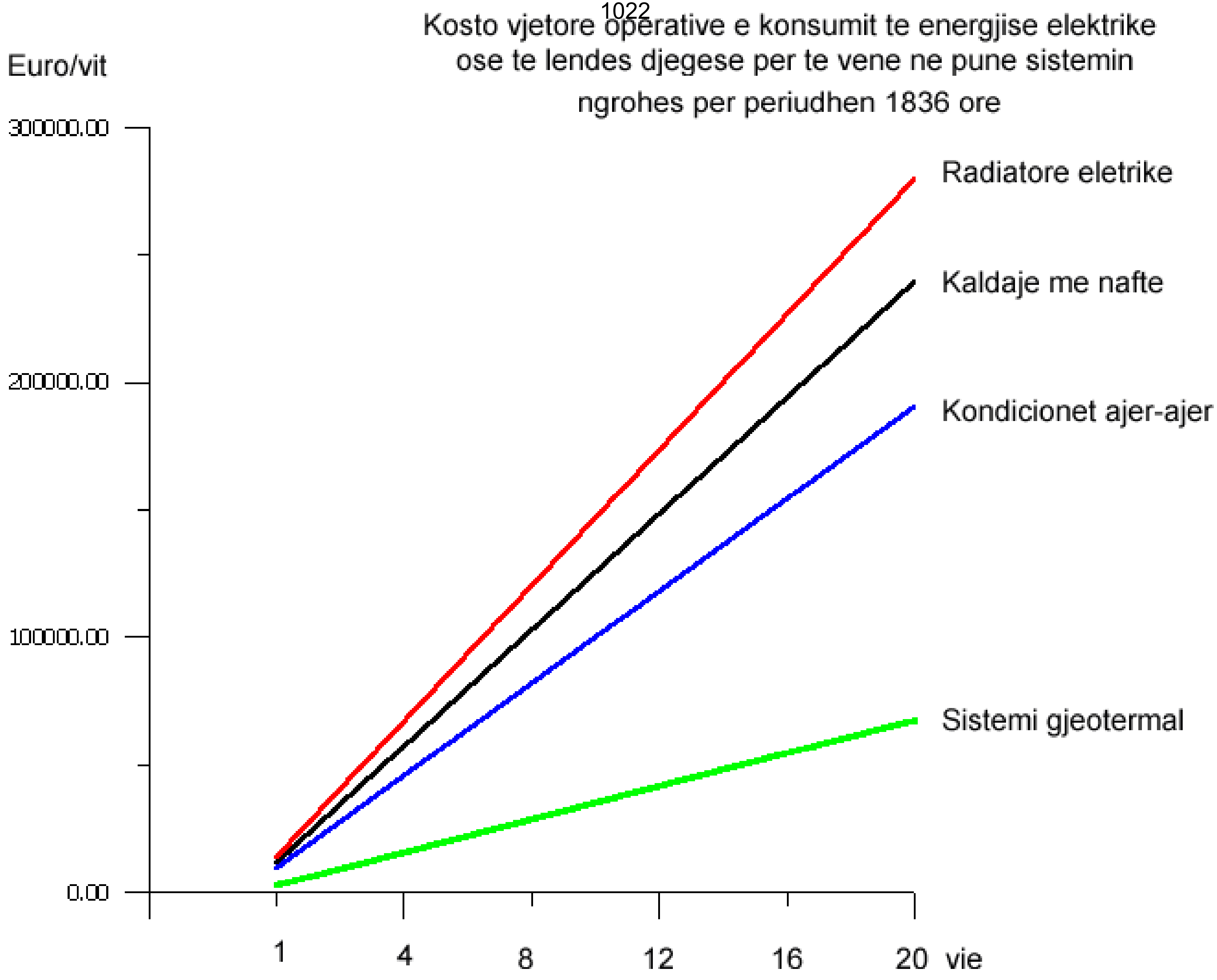
Kosto parapraake totale vjetore për energjinë ngrohëse:

- **Euro/KW**	**Viti parë**	**Viti dytë**
A Pus-pompë gjeotermale nxehtësie	677,14	49,40
Pus-kem. V. nxeht.-pom.gjeo.nxehtësie	1.048,83	174,93
Kaldajë me naftë	569,08	138,91
Kondicionerë	366,79	204,28

- Euro/m^2		
Pus-pompë gjeotermale nxehtësie	76,04	5,55
Pus-kem. V. nxeht.-pom.gjeo. nxehtësie	117,78	5.55
Kaldajë me naftë	63,90	19,64
Kondicionerë	41,19	15,60
Radiatorë elektrikë	22,04	22,04



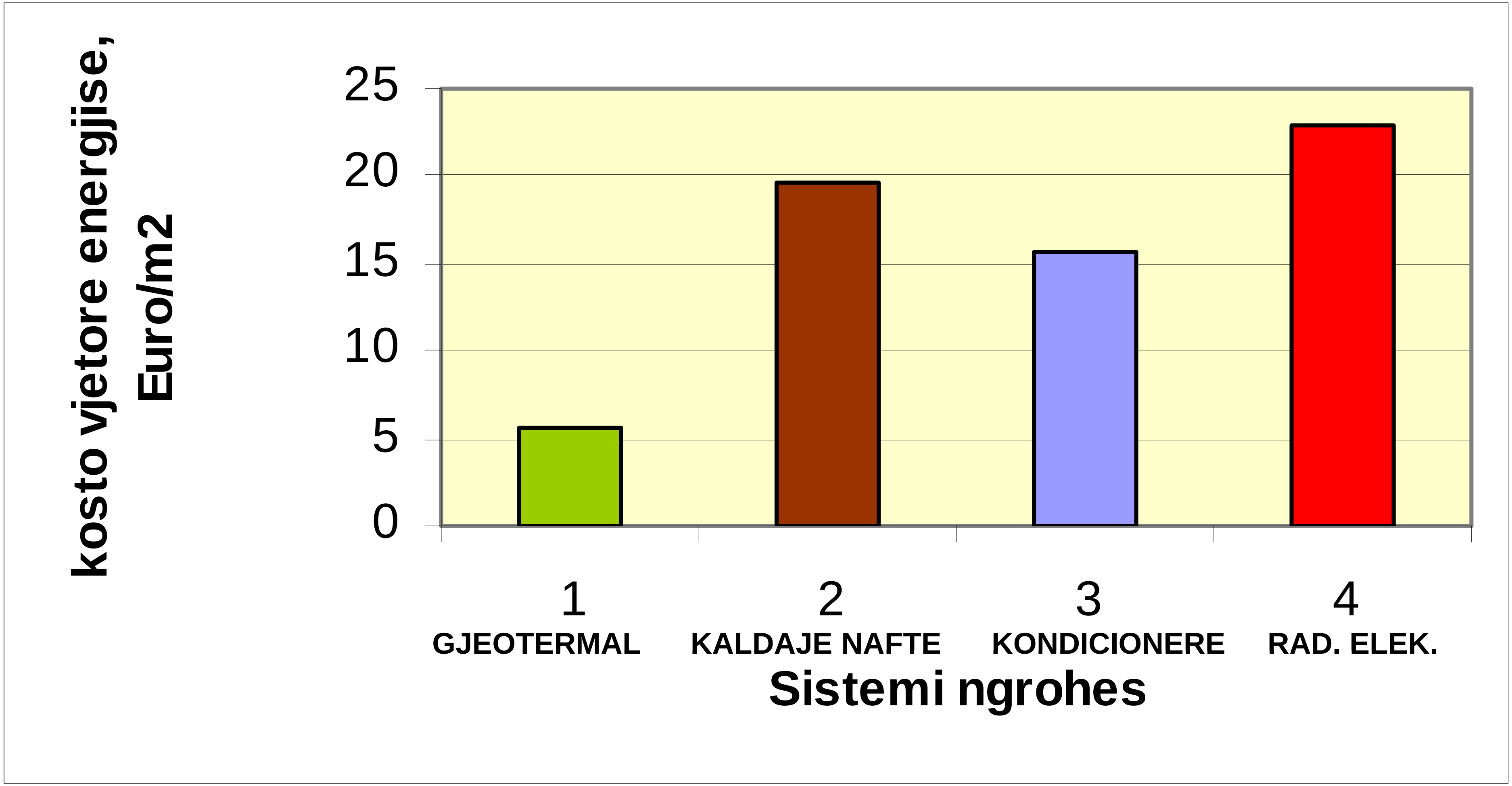
Kosto kumulative vjetore e ngrohjes
(Periudha e ngrohjes 1836 ore)
Euro
300000.00
200000.00
100000.00
0.00
1
4
8
12
16
20
vjet
Sistemi me kaldaje me nafte
Sistemi me kondicioner ajer-ajer
Sistemi Pus-kembyes v. nxehtesie
-Pompe nxehtesie
Sistemi Pus-Pompe nxehtesie


Kosto vjetore operative e konsumit te energjise elektrike
ose te lendes djegese per te vene ne pune sistemin
ngrohes per periudhen 1836 ore
Euro/vit
300000.00
200000.00
100000.00
0.00
Radiatore eletrike
Kaldaje me nafte
Kondicionet ajer-ajer
Sistemi gjeotermal
1
4
8
12
16
20
vie

- . Duket qartë se *periudha e vetshlyerjes së investimeve për sistemin “pus-pompë gjeotermale nxehtësie”* është:

- 1 vit. Ajo mbulohet vetëm me shpenzimet që do të bëheshin për naftën e kaldajës

- 5 vjet. Ajo mbulohet vetëm me shpenzimet që do të bëheshin për energjinë elektrike të kondicionereve.


kosto vjetore energjise, Euro/m2
25
20
15
10
5
0
1
GJEOTERMAL
2
KALDAJE NAFTE
3
KONDICIONERE
4
RAD. ELEK.
Sistemi ngrohes

1) Konsiderata ekonomike. aktualisht, kosto e instalimit te KVN-PN është më e madhe sesa e instalimeve konvencionale me karburant. megjithë këtë kosto vjetore e “karburantit” te sistemit KNP (energjia elektrike për pompën e nxehtesise dhe pompat e qarkullimit) janë në mënyrë të konsiderueshme shumë më të ulta sesa karburanti i një ngrohësi konvencional me naftë ose gaz. kursehet deri 70% e energjisë elektrike. kështu koha e kthimit të shpenzimeve të knp është më e shkurtër se koha e punës së vetë sistemit ngrohës.

2) Konsiderata mjedisore. KNP-pompë termike është një sistem mjedisor i pastër që nuk emeton gaze CO_2 (“efekti serë”), kështu që evitohet për pronarin e shtëpisë pagesa e taksës për emisionin e gazeve co_2, e cila është në diskutim në vendet e komunitetit europian.

3) **Mbeshtetje Qeveritare**. Qeveria Japoneze investon 200 USD per cdo kilovat te Pumpes Gjeotermale, me nje limit te siper prej

5 200 USD.

In Tirana center

Tirana International Hotel Climatization by air-air chillers.

New
Busines & Residential Premises

Heating/colling by:

a) **Air conditional small units**
b) **Oil/gas fired boiler for each apartment separately**

THIRRJE PËR INVESTIM

Zgjidhja ekonomike e problemit të ngrohjes në Shqipëri është një detyrë e ditës, tepër e rëndësishme, veçanërisht më kushtet e krizës energjetike që po kalon vendi. Një ndër rrugët e duhura është përdorimi i energjisë gjeotermale.

Në Shqipëri ka një bum në ndërtimet e godinave të larta shumëkatëshe. Ato ende projektohen të ngrohen me kaldaja me naftë ose me gaz, si edhe me kondicionerë ajër-ajër. Në të gjitha godinat e institucioneve shtetërore ngrohja dhe freskimi bëhet me kondicionerë ajër-ajër, spitale, konvikte, hotele, etj ngrohen me sistemin me kaldaja me naftë ose me qymyr.

Ka ardhur koha, që të dilet mbi synimet e

- **Bisnesmenëve që tregëtojnë naftgë e gaz,**

- **Mbi praktikat e konsumit të energjisë elektrike që paguhet nga buxheti i shtetit, ose që nuk paguhet ende.**

Futja e sistemeve ngrohëse dhe freskuese me anën e energjive të rinovueshme, midis të cilët atë të nxehtësisë së Tokës, duhet të fillojë të mos mbetet ne instalimet demostrative.

Me realizimin e këtij propozimi i bëhet apel:

Administratës shtetërore që mbulon problemet energjetike,

- **Komunitetit të biznesit si edhe**
- **Opinionit tekniko-shkencor, që të krijojnë mundësi për të bërë ngrohjen e banesave sa më ekonoimike dhe sa më mirë.**

Shteti, me levat e veta ekonomike duhet të stimulojë futjen edhe në Shqipëri të këtyre sistemeve moderne dhe shume ekonomike e miqësore me mjedisin.

Komuniteti i biznesit duhet ti njohë dhe të investojë për ndërtimin e sistemeve Këmbyes Nxehtësie-Pus-Pompë Gjeotermale Nxehtësie, duke hapur rrugë për biznese të reja, në plan kombëtar.

Universitet teknike të shpërndajnë njohuritë për këto sisteme bashkëkohore dhe të bëhen nxitës të zbatimit të tyre në Shqipëri.

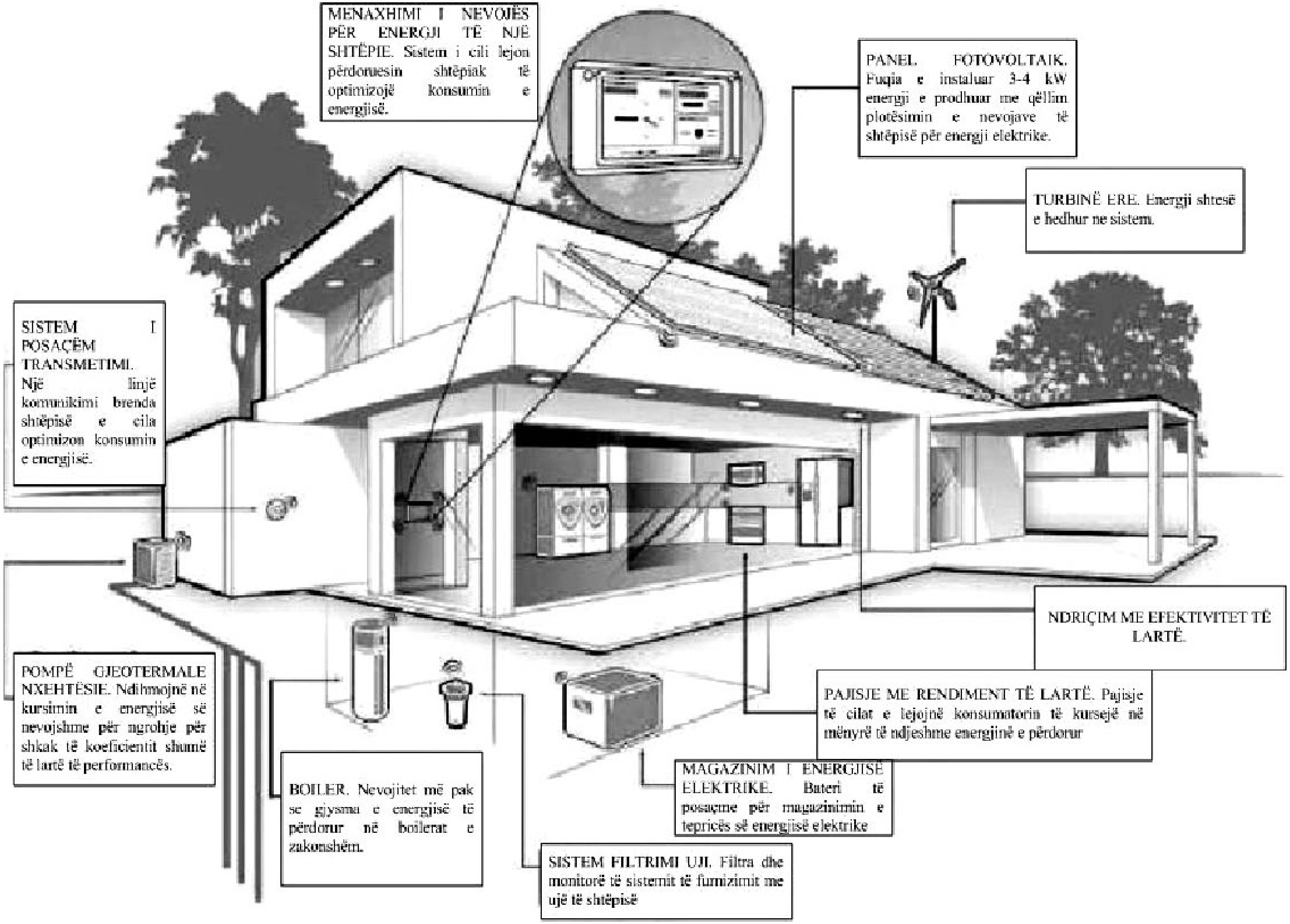
Investimi i nevojshem

Për ndërtimin e sistemit gjeotermal të ngrohjes kërkohet investim në masën që përcaktohet në varësi të madhësinë së godinës që do të ngrohet.

Mbështetur në analizën e kostos së bërë më sipër, kosto e instalimit për këto sisteme që bazohen në nxehtësinë e ujërave nëntokësore janë :

70-150 Euro/m^2.

SHTËPITË ME ENERGJI ZERO, OSE SHTËPITË PASIVE



Shfrytëzimi i energjisë gjeotermale në Shqipëri duhet të fillojë sa më parë, me anën e projekteve të përshtatshëm. Është një investim me efektivitet ekonomik të lartë.

FALEMINDERIT PER VEMENDJEN

BGS 6TH CONGRESS, Budapest, 2-6 October 2011

ORIGIN AND TEMPERATURE PROFILES OF THERMAL WATERS FROM THE DEPTHS OF THE ALBANIDES

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ABSTRACT

In this paper, geological data on the depth of origin and temperature profiles of thermo-mineral waters are presented. Albania is rich in geothermal resources of low enthalpy with geothermal energy located in different areas of the country and thermo-mineral waters of sulphate, sulphide, methane and iodinate-bromide types located in three geothermal zones. The location of geothermal springs, their reservoirs and physic-chemical properties of the waters, geothermal regime of the geological structures of the Albanides based on temperature at different depths, geothermal gradient and heat flow density are here analysed in detail. This study is an integrated part of interpretation of geological settings in Albania, contributing in two main fields: i) regional geological field of the Albanides, depth ruptures, etc., and ii) regional and local studies focused on potential of thermal and mineral water resources and the geothermal market in Albania. Both of these aspects are here presented and analysed.

Keywords: thermo-mineral water, heat flow density, geothermal gradient, geothermal zone

1. INTRODUCTION

Albania is rich in low-enthalpy geothermal resources and mineral waters. The amount of geothermal energy produced from low-enthalpy resources and the large number of mineral water sources provide not only a basis for successful application of modern energy technologies in the country, but also an opportunity for effective economic and successful integrated and cascade use of geothermal energy. Thermo-mineral waters, their geothermal properties, heat flow density, geothermal gradient and temperature are important signals that can be taken from the geological depths of the Albanides, geological structures located in Albanian territory.

Much research has been carried out on geothermal, hydro-geological, hydro-chemical, biological and medical effects of thermal and mineral water resources, the results of which are depicted in maps and geothermal sections. Temperature maps along with geothermal gradient, heat flow density and geothermal resources maps have been compiled for depths of down to 3,000m. Natural thermal water springs and geological structures with a high water temperature have also been investigated.

One of the aims of the present study was to identify the relationship between the high temperature of these spring waters and their origin. Geological data gathered from the depths of the Albanides are analysed based upon a complex set of geothermal signals.

2. METHODS

Studies into geothermal fields and evaluation of geothermal energy in Albania (illustrated in Frashëri et al., 2004; Frashëri and Kodhelaj, 2009) were carried out on the basis of temperature logs at 84 deep oil and gas wells and 59 shallow boreholes. The results of the

geothermal studies are illustrated in maps and geothermal sections, including temperature maps for depths down to 3000m, geothermal gradient maps, heat flow density and geothermal resources. The natural springs of thermal waters and their reservoirs have already been investigated. A platform of integrated and cascade use of geothermal energy resources in Albania was performed in 2009, within the framework of the National Water and Energy Research and Developing Programme 2007–2009 (Frashëri and Kodhelaj, 2009).

3. RESULTS AND DISCUSSION

Thermo-mineral waters of low enthalpy

Figure 1 depicts many of the thermal springs and wells of low enthalpy in Albania, located mainly in areas of regional tectonic seism active fractures. Thermal sources are located in three geothermal zones:

1) Kruja geothermal zone extends from the Adriatic Sea in the North down to South-Eastern Albania, at the border with Greece. Geothermal aquifers are represented by a karstified neritic carbonate formation of numerous fissures and micro fissures.

At the northern part of the region some springs and deep wells of discharged thermo-mineral waters meet. The hot waters are of type Mg–Cl and have salinity varying from 4.6 to 19.3g/l, Ca, Na, Cl, K, SO_4, SO_4, HCO_3, and H_2S, pH value between 6.7 and 8, and density from 1.001 to 1.006g/cm^3. The thermal waters of Nosi Spring contains less than 1.2 TU tritium (^3H) and –7.66‰ Standard Mean Ocean Water (SMOW) $\delta^{18}O$. The low level of tritium indicates that these thermal waters were created centuries ago. Wellhead temperatures in the Tirana–Elbasan northern sub-zone vary from 60 to 65.5°C. In hole Kozani 8, the temperature at the top of aquifer reaches 80°C. According to the temperature logs for Ishmi 1/b and Galigati 2, temperatures deep in the carbonate section are, respectively, 42.2°C and 52.8°C, while the aquifer temperatures, according to Fournier, Truesdell and Na+K+Ca geothermometers are respectively 254°C, 235°C and 143°C.

The Lëngarica River thermal springs, Postenani steam springs and Sarandaporo springs are located in the southern sub-zone of the Kruja geothermal area. Thermal water discharges as a result of contact between Eocene fissured, karstified limestone and the flysch section. The steam flows upwards from the tectonic fault. Waters do not contain H_2S and CO_2. They have a mineralization factor from 7 to 9 times less than that in the northern sub-zone. The water temperature is 29°C, while the discharge varies between 30 and 40 l/s. In the Kruja geothermal area most of Albania's geothermal resources are located. For the Tirana–Elbasan northern sub-zone the specific reserves vary from 38.5 to 39.6 GJ/m^2. The southern sub-zone has a lower concentration of resources of 20.63GJ/m^2.

2) Located in the coastal area of Albania, Ardenica geothermal zone comprises the molasses Neogene brachyanticlines and the northern pericline of Patos–Verbas carbonate structure, with the overlying Neogene molasses and it is intercepted by the Vlora–Elbasan–Dibra transverse fault. The Ardenica geothermal reservoir comprises sandstone sections of Serravallian, Tortonian and Pliocene age. Hot water discharges from some deep wells. Water flowing into these boreholes discharges from a depth interval varying from 1,200 to 3,758 m. The thermal waters are of type Ca–Cl type and contain between 21.2 and 33 mg/l iodine, 110mg/l bromide and 71mg/l boric acid. Aquifer temperatures are higher in the sandstone layer than in any other layer. At the wellhead, temperatures vary from 32 to 67°C, while the resources density range from 0.25 to 0.39 GJ/m^2.

3) Peshkopia geothermal zone is located in North-East Albania. Water at 43.5°C discharges from a group of thermal springs with a yield up to 14 l/s. The occurrence of these springs is associated with a deep fault at the periphery of a gypsum diapir of Triassic age penetrating the Eocene flysch. A deep fault represents a seismoactive tectonic belt. The thermal waters are of SO_4–Ca type, with mineralization of up to 4.4g/l and containing 50mg/l H_2S.

Geothermal regime of the Albanides

The tectonics of the region, lithology of its geological section and the local thermal properties of the rocks and geological location impact the Geothermal Regime of the Albanides.

At a depth of 500m, the geothermal field is characterized by relatively low temperatures, from 20°C to 21°C. In the Peri-Adriatic Depression, wells at a depth of 1,000m have a higher temperature, of up to 36°C. At a depth of 6,000m, in the central part of the Peri-Adriatic Depression, the temperature is 105.8°C. The isotherm runs parallel with the Albanides strike. The temperatures in the ophiolitic belt are higher than in the sedimentary basin at the same depth.

In the Pliocene clay section, at the centre of the Peri-Adriatic Depression, the geothermal gradient displays the highest value, about $21.3mK.m^{-1}$. The largest gradients are detected in anticline molasses structures. The gradient decreases from 10 to 29 per cent where the limestone core of anticlines in the Ionic tectonic zone is located, showing that in a depth of 20km a decrease in the gradient could be observed. This change in gradient coincides with the top of the crystal basement. In the ophiolitic belt of the Mirdita tectonic zone, in north-eastern and south-eastern Albania, the geothermal gradient values increase up to $36mK.m^{-1}$. Following geothermal modelling, the gradient decrease could be observed also in an area deeper than 12,000m at the ophiolitic belt, at the top of the Triassic salt deposits.

In Albanides, the thermal field scattering (Figure 2) of heat flow density regional pattern is characterized by the highest value of heat flow, $42mW/m^2$ in the centre of the Peri-Adriatic Depression. The $30mW/m^2$ value isotherm is open towards the Adriatic Sea shelf. Heat flow density values are lower than $25–30mWm^{-2}$ in the Albanian Alps area. This phenomenon has occurred because of the great thickness of sedimentary crust, mainly carbonate, in this zone. In the ophiolitic belt in eastern Albania (Qirinxhi, 2006), heat flow density values go up to $60mW/m^2$ (Frashëri et al., 2004). Heat Flow Density contours offer a clear configuration of the ophiolitic belt.

Origin of thermo-mineral waters and temperature depth signals

The entire water chemical composition and the geological setting of geothermal systems in the Albanides have been investigated to evaluate the origin of the dissolved constituents and mechanisms of water–rock interaction. The temperature of 80–100°C of thermal waters at the top of the limestone and sandstone reservoirs at a depth of 1,000–3,500m, higher than those (40–60°C) of the surrounding geological section at the same depths, indicates that the brackish thermal fluid moves upwards to the surface from deeper horizons. The faults are seismological active belts, providing a preferentially upward path for the warm waters, allowing them to travel at depths without losing heat (Figure 3). The temperatures of 150–250°C at the aquifers, where brackish thermo-waters are formed, according to the geothermometers data, indicate clearly that the depth of the aquifers ranges from about from 15 to 20 km, based on geothermal modelling (Figure 4).

Faults were generated as a result of the compression stress leading to rock deformation. Correlation among tectonics, seismological activity and geochemical features of the circulating fluids indicate that these fluids comprise water extracted from the rocks as a result of compression stress.

Composed mainly of massive gypsum, the outcrops of salt bodies are encountered in different zones of the Albanides. In Peshkopia, in central-eastern Albania, gypsum bodies can be massively found, representing a tectonic window, surrounded by Palaeogenic and Palaeozoic rocks of the Korabi tectonic zone. Some gypsum bodies locally found are composed of different halogen salts such as rock salt (NaCl) and sylvine (KCl), outcrops among Jurassic, Cretaceous, Palaeogene carbonate rocks and Palaeogene flysch. These are related to thrusts and developed in the Ionian tectonic zone (Qirinxhi et al., 1991). The outcrops in the Dumrea region, of a large gypsum body, surrounded by Neogene rocks, are also related to the thrust. This is the so-called Dumrea gypsum stock, a very large tectonic wedge, for long time incorrectly regarded as a diapiric body. Once the tectonic stresses, related to the Alpine Post-Oligocene and Post-Tortonian Tectogenesis (Qirinxhi et al., 1991) appeared, all the aforementioned gypsum and gypsum-halogen salt bodies moved upwards.

The geological and geophysical data show the gypsum and halogen-salt horizon lying under carbonate Triassic rocks, though previous studies mark gypsum and halogen-salt rocks belonging to the Triassic age. This incorrect stratigraphic analysis was a consequence of the interpretation of contact between the calcareous rocks of Upper Triassic age, gypsum and halogen-salt rocks in the Ionian tectonic zone. This issue is also depicted in the most recent geologic map of Albania (Institute of Geologic Research, 2002; scale 1:200,000). However, gypsum and halogen-salt rocks in Albania are of Permian age, representing pre-Alpine platform formations, from a geological point of view analogous to their homologues, well known in different regions of European countries (in e.g. Russia and Germany), and in Asia (e.g. Uzbekistan, Dagestan; Betechtin, 1956). Gypsum and halogen salts were formed in the Permian, in a shallow of a very large sea basin(s) under arid climate conditions, widely spread in the area of Laurasia, or in all the submerged continents of the World.

Geothermal fluid moves upwards through the Paleozoic gypsum–halogen-salt bed at the bottom of the sedimentary crust, and bodies outcropped up to surface. Moving towards the surface, thermal waters may become abundant with various chemical elements and at a shallow depth polluted by underground water, creating their chemical composition.

At a depth of more than 150m, the gypsum is formed mainly from anhydrous $CaSO_4$ as a result of the reaction $CaSO_4 + 2H_2O = CaSO_4 - 2H_2O$. Thermal waters coming from the depth penetrate the gypsum horizon, following faults or between-layer surfaces, dissolving them, becoming first enriched with sulphuric acid. They are mostly enriched through dissolution of disseminated pyrite crystals from diabase and amphibolite, mostly present in a deep area near the gypsum horizon. Their outcrops near the gypsum layer, in the Ionian tectonic zone (Qirinxhi, 1970) are a clear confirmation of this analysis. Enriched in SO_4^{--} and in Ca^{++}, thermal waters have more dissolvent capacity as they dissolve gypsum and bring also from each molecule the water released from the dissolved gypsum. The same process takes place with the halogen salts. After dissolution, cations and anions pass into the thermal waters transformed in thermal-mineral waters, still containing the cations and anions.

The occurrence of thermal-spa waters, related to the presence of a major fault system and deep origin of the geothermal fluids, is the basis on which these faults represent the regional deep fractures.

The heat value is less than the continental average. In the Albanian sedimentary basin, at the centre of the Peri-Adriatic Depression of the External Albanides, this low heat value has occurred due to the great thickness of a mainly carbonate sedimentary crust in the zone. Radiogenic heat generated in the ophiolites is very low. under such conditions, increase in heat flow in the ophiolitic belt is related to heat flow transmitted from depth. The highest value of the heat flow density in this belt is the consequence of smaller thickness of the geological section at the top of the crystalline basement, and the MOHO discontinuity. The granites of the crystalline basement along with the radiogenic heat generation comprise the heat source. In the ophiolitic belt there are some hearths observed of higher heat flow density. Heat flow anomalies are based on intensive heat transmitted from deep and transversal fractures.

4. CONCLUSIONS

This paper highlights three main issues. Firstly, at a depth of 15–20 km, thermo-mineral spring waters in Albania are of tectonic stress origin. Secondly, thermal waters generally rise from depth from a Triassic–Paleozoic salt bed at the bottom of the sedimentary crust. The permeable fault zones, seismologically active, provide the upward path of the thermal fluids. Near the surface, these waters mix with cold fresh underground water from limestone or sandstone structures. Finally, the granites of the crystalline basement, combined with the radiogenic heat generation, provide the heat source in the ophiolitic belt of the Albanides, with the small thickness of the geological section at the top of the crystalline basement.

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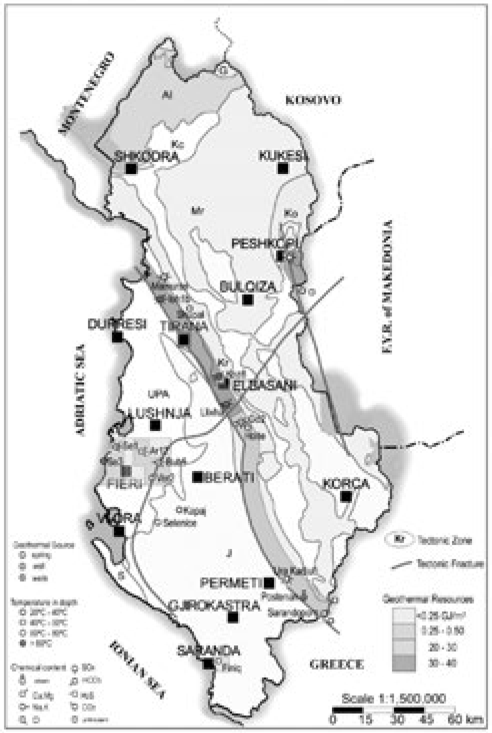
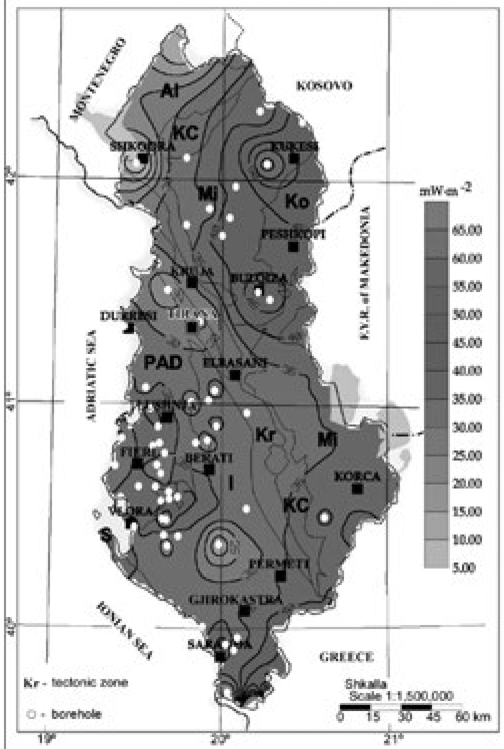
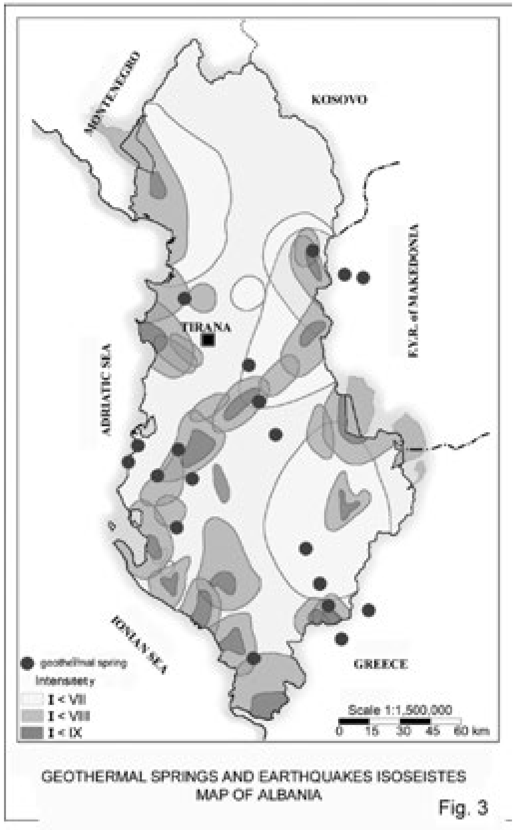


GEOTHERMAL ZONES MAP IN ALBANIA Fig. 1



HEAT FLOW DENSITY MAP OF ALBANIA

Fig.1



GEOTHERMAL SPRINGS AND EARTHQUAKES ISOSEISTES MAP OF ALBANIA

Fig. 3

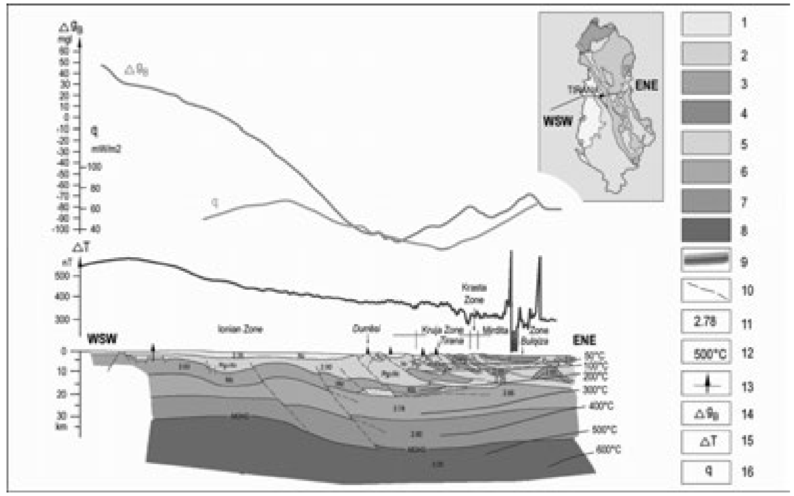


Fig. 4. Geophysical regional profile Albanid 1:
Falco Adriatic Sea–Durrës–Tirana–Peshkopi
(gravity data for Adriatic Sea after Richetti, 1980).
1, Pliocene (N_2); 2, Lower Miocene (N_1)–Paleogenic flysch (Pg_3); 3, Mesozoic limestone (Mz); 4, Ultrabasic rocks; 5, Salt; 6, Crystal Basement; 7, Basalt Crust; 8, MOHO Discontinuity; 9, Depth up–disjunctive tectonic; Density, g/cm^3; Temperature, °C; 13, Deep well; ΔG_B, Bouguer Anomaly; T, Total Magnetic Field Anomaly; q, Heat Flow Density.

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OUTLOOK ON MULTIDISIPLINARY INTEGRATED GEOPHYSICAL-GEOLOGICAL STUDIES FOR SLOPE STABILITY INVESTIGATION AND LANDSLIDE MONITORING PRIOR TO ANY DEVELOPED AREAS IN ALBANIA

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Abstract

Slope stability investigation and landslide monitoring in the framework of the emergency situation in Albania are presented in the paper. Albania is a mountainous country and geological structures represent a environment with possibilities for instable slopes and landslide developments. Based on the geological formations and landslide body mass, can be present following landslide classification in Albania:

- Instable slopes and intensive landslides developed in weathered bedrocks and in overburden bed at the lakeshores of hydropower plants.
- Instable slopes and intensive landslides developed in Oligocene flysch formation.
- Instable slopes and landslides developed in Neogene's molasses formations.
- Landslides developed in loose Quaternary deposits.
- Downfalls in the weathered rocks

Developing of new landslides or re-activation of the old ones is mainly due to human activities. Special constructions, such as hydrotechnical works, civil, industrial, urban and rural and infrastructure constructions, particularly during last decade, as well as destroyed equilibrium in ecological systems through deforestation etc., all these events have contributed to landslide development. Landslides are located in the deluvial deposits, and in the altered-bedrocks. The slipping bodies of some landslides have very big volume, more than 40 million cubic meters. The biggest ones are observed at lakeshores near of hydropower plants, which are presented a great geological hazard. Actually is very important to avoid natural risks related to the slope instability and landslide development.

Periodical multidisciplinary integrated engineering geophysical-geological-geodesic methods of innovative technologies in investigation of slope stability and landslide monitoring have been included in survey system. In-situ multidisciplinary geophysical-geological-geodesic investigation and monitoring have been realized in three phases:

1. Surface integrated geological-geophysical survey and installation of geodesic markers.
2. Drilling of shallow boreholes.

a) To study the landslide body structure and soil of the landslide area,

b) Evaluation of in-situ physical-mechanical properties of soils and rocks,

c) Hydrogeologcal surveys, and

3. In-situ monitoring of landslide phenomena.

The basic method have been the seismic tomography and high frequency refraction seismic profiling. The natural seismic-acoustic activity inside and outside of slipping body have been observed. According to the surveys' data the velocity of P-waves (Vp) and S- waves (Vs) have been study slipping body structure and determined the physical-mechanical properties of the soil and rocks. Electrical soundings have been performed by the Schlumberger array, with survey depth of 120-150 m. Together with the geophysical methods mentioned above, the micro-magnetic and micro-gravity surveys have been the part of the integrated investigation of landslide areas. Micro magnetic mapping present important information for landslide activity prognostic.

Set up for the first time of innovative observation systems of multidisciplinary integrated remote sensing-geophysical-geological-geodesic technologies for slope stability investigation and landslide monitoring prior to areas in near hydropower plant and any city present the main future program goal. The transferring of the new technologies for the investigation and monitoring of the landslides will allow being undertaken technical-engineering measures necessary for the elimination or reduction of the negative environmental effects of the land-sliding phenomenon. Develop technology and set up of two innovative observation stations for multidisciplinary monitoring of two biggest and most dangerous landslides in Albania have been programmed.

Conclusions

Based on the surveys analyses can be reached the following conclusions:

1. In the profiles, where integrated geophysical surveys have been conducted, are fixed the bodies of the studied landslides. In these profiles are also clearly fixed the sliding plains. In general, even though the geological conditions in which these slides have been developed are different, the plains have regular configuration, with maximum deepness in the center of the profile.
2. The slipping body, very often, is made of several slipping plains of block like character. Especially active today, are the slipping plains located 15 - 20 m deep. The slipping body over this plain is mainly made of deluvial - eluvial sediments, or rocky masses with very weak physical - mechanical characteristics. Their dynamic is causing more damages every day to the houses of the Porava village.
3. The Porava landslide is the biggest slide studied till now. The lower plane of this landslide is located about 100 - 160 m deep. It separates the Lower-Middle Triassic volcanogenic-sedimentary rocks, with very low petrophysical characteristics from the volcanogenic-sedimentary deposits untouched by the sliding phenomena. The total volume of the whole slipping body, from some approximate calculation based on these preliminary geophysical data, is estimated to be over 40 million m^3.
4. The structure of the slipping body and its dynamic stands in the foundation of the patterning on the landslide development. Besides the others, the height of the dam is directly defined from this pattern. Accepting the slipping body as a unique mass, has sent to the over heightening of the dam and greater expenses.
5. The block-like character of the sliding bodies brings to the conclusion that the block of these bodies can not fall down immediately in any kind of velocity.

1. Presentation of the problem:

Albania is a mountainous country and Albanides are represented geological structures with possibilities of instable slopes and landslide development (Fig. 1).

Based on the geological formations and landslide body mass, can be present following landslide classification in Albania:

- Instable slopes and intensive landslides developed in weathered bedrocks and in overburden bed at the lakeshores of hydropower plants.
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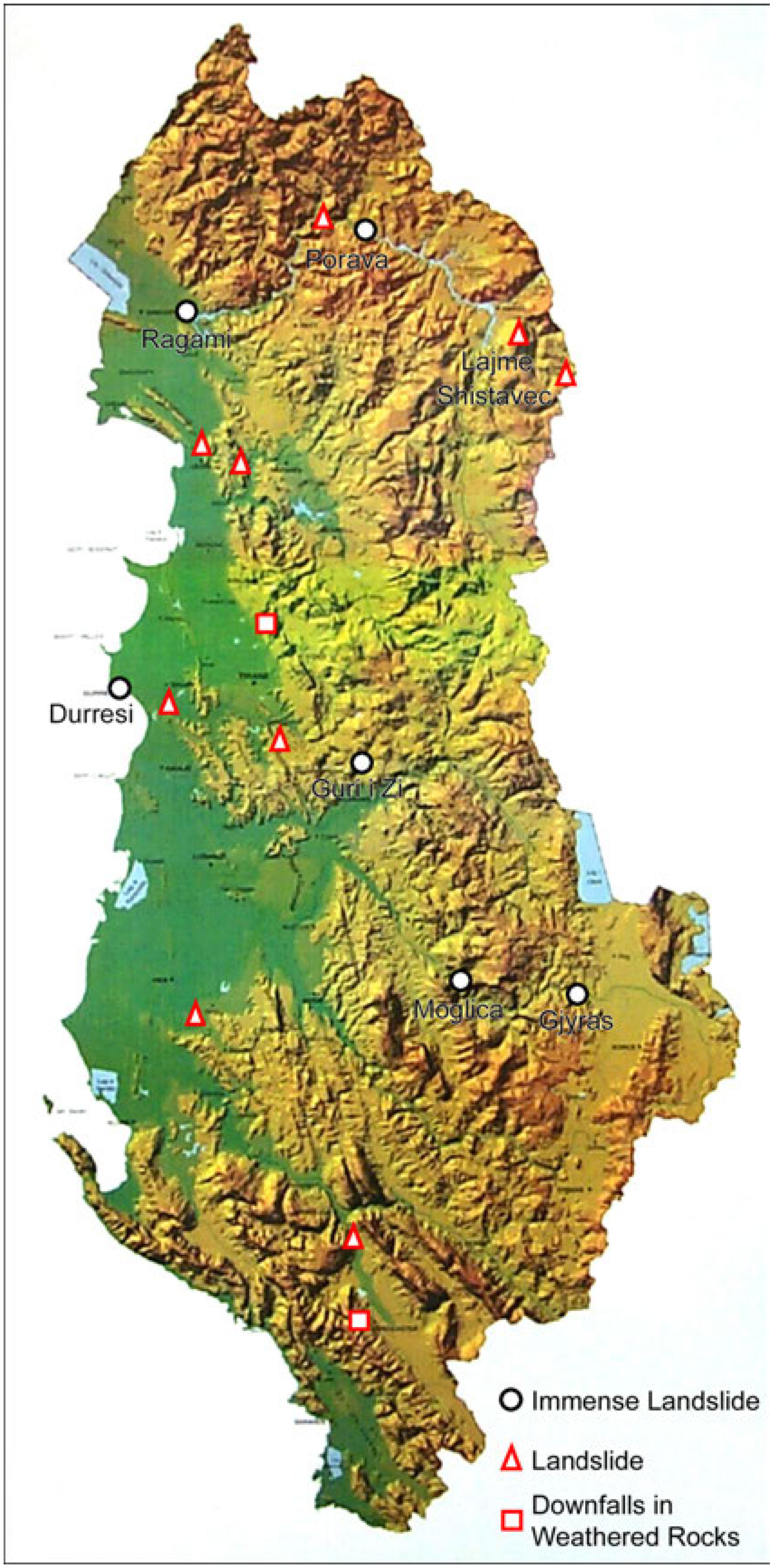
- Landslides developed in loose Quaternary deposits.
- Downfalls in the weathered rocks

Developing of new landslides or re-activation of the old ones is mainly due to construction works. Special constructions, such as hydrotechnical works, civil, industrial, urban and rural constructions and constructions in the infrastructure, particularly during last years, as well as destroyed equilibrium in ecological systems through deforestation etc., all these events have contributed to landslide development. Landslides are located in the deluvial deposits, and in the altered-bedrocks. The slipping bodies of some landslides have very big volume, more 50 than million cubic meters. The biggest ones are observed near of hydrotechnical works.

1.1. Integrated geological-geophysical in-situ investigation for landslide prognosis, study and monitoring.

In-situ investigations and monitoring for investigation for landslide prognosis, study and monitoring were carried out by integrated engineering geology-geophysics methods:

- Geological Mapping
- Geomorphological Mapping
- Hydrogeological Mapping
- Engineering Geological Mapping
- Geophysical Mapping, in-situ investigation and monitoring
    - Gravity micro survey
    - Magnetic micro survey
    - High Frequencies Seismic Tomography and profiling.
    - Geoelectric Tomography, electric soundings and profiling, etc.
    - Electrical, radiometric, sonic etc. well logging
- Laboratory analysis and determinations
- Geodesic observations.


Porava
Ragami
Lajme
Shistavec
Durresi
Guri i Zi
Moglica
Gjyras
Immense Landslide
Landslide
Downfalls in Weathered Rocks

In-situ geophysical investigation and monitoring are programmed to performed in three phases:

1. Surface integrated geological-geophysical survey and installation of geodesic markers.
2. Drilling of shallow boreholes, cross-hole seismic survey and well logging.
3. Periodical geophysical surveys and geodesic observations in boreholes and on the ground surface.

Consequently, geophysical-engineering studies have a complexe character:

a) To prognoses slope instability and landslide development possibility in the future,
b) To study the landslide body structure and soil of the landslide area,
c) Evaluation of in-situ physical-mechanical properties of soils and rocks and
c) In-situ monitoring of landslide phenomena.

The basic method is the seismic tomography and high frequency refraction seismic profiling. The tomography can be combined with refraction seismic profiling of high frequencies at different sectors of the landslide area. Geophone setting in the survey line had distances from 1-50 meters, according to the object size and the required seismic depth investigation. The longitudinal and shear waves were recorded through the time intercept method. The hole-hole seismic tomography of longitudinal and shear waves can be included in the surveys program. The natural seismic-acoustic activity inside and outside of slipping body is necessary to observe. According to the surveys' data the velocity of P-waves (Vp) and S- waves (Vs) can be calculated, as well as the layer thickness. According to all the seismic data, the physical-mechanical properties must be calculated for the soil and rocks as Poisson coefficient, elasticity dynamic modulus of, Bulk modulus, rigidity modulus and module of compression volume strength.

Electrical soundings can be performed by the Schlumberger array, with spacing up to AB/2 = 500 m, which allowed to reach a survey depth of 120-150 m. Resistivity profiling can be carrying out by multiple Schlumberger arrays with two-five investigation depths, relating to the required depth of investigation for each object. It is necessary evaluating of the anisotropy of geoelectrical section. Geoelectrical tomography to investigate the landslide area must be included in the investigation program. Resistivity Realsection of the geoelectric tomography can be performed by multiple spacing gradient arrays, with maximal spacing in dependence of the investigation depth.

Together with the geophysical methods mentioned above, the micro-magnetic and micro-gravity surveys are part of the integrated investigation of landslide areas. Micro magnetic mapping present important information for landslide activity prognostic.

The gamma-gamma density logging, neutron-gamma logging, electrical logging, acoustic logging and inclinometers can be applied for boreholes documentation.

Samples of soil and rocks from the studied area must analyzed in the laboratory for determination of their physical-mechanical properties and for further petrological studies of thin sections.

In Albania, the study of the shape and structure of the slipping body, estimation of physical-mechanical properties of the slipping body and of the bedrocks, and evaluation of

the level of the landslide natural seismic-acoustic activity were carried out using the results based on the interpretation of geophysical surveys. Physical-mechanical properties of the rocks in the landslide area have documented their important role in relation to the slipping body mapping, study of slope stability and dynamics of the landslide's development.

1.2. Discussion and Analyses

There are analyzed some representative results from the investigation of slipping in Albania, which have been developed in different geological conditions. There are discussed the possibility of using geophysical studies to learn about the slipping phenomena and situation in the condition of the geomorphologic architecture of a mountainous country as Albania. The results of the geophysical data for in-situ evaluation of the physical-mechanical properties of the rocks in the unstable slopes is included in this analyze.

1.2.1. Landslide at the lakeshores of the hydropower plants.

Hydrotechnical works in Albania are generally constructed in conditions of rugged terrain and in geological formations in which the land sliding phenomena is often present. The land sliding phenomena develops in the basement rocks and the overlaid loose sediments. This phenomenon has been more evidently activated after the construction of hydrotechnical works.

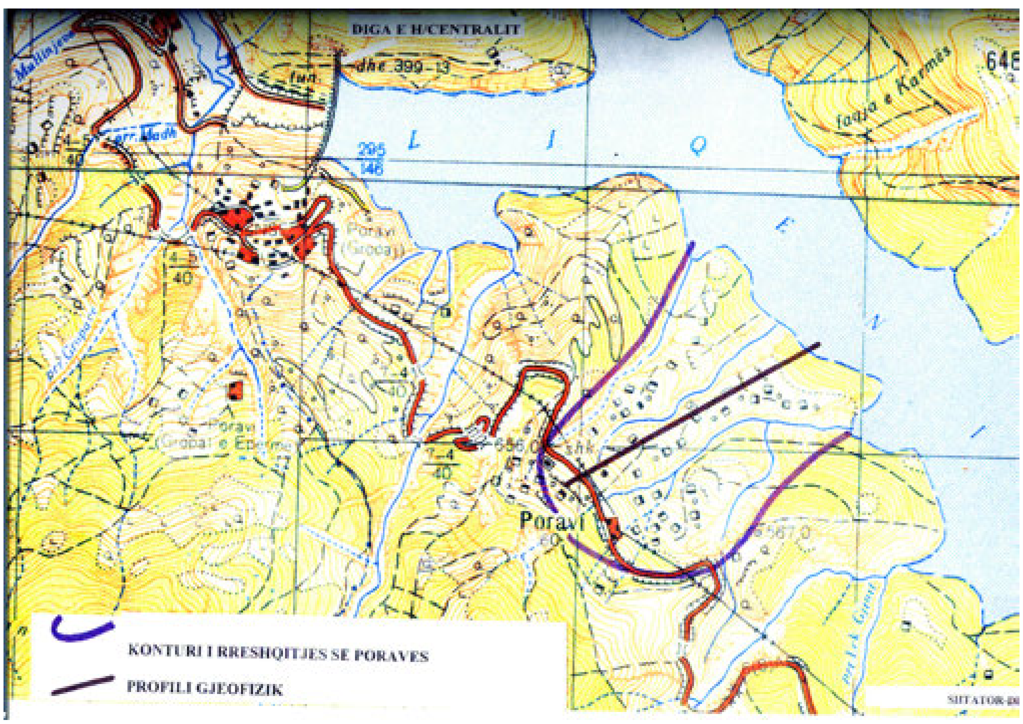
The exploitation period of more than 25 years of such a huge hydrotechnical work has influenced to the physical-mechanical properties at various parts of this landslide.

1.2.1.1. The Porava Landslide

A study conducted in the Fierza hydropower plant, constructed over the Drini River in Northern Albania, is a clear example of it. This hydropower plant was build in 1974 and has an installed capacity of 500 MW. The lake, created after the construction of the plant, has a water volume of 2.7 billion m^3. The hydropower plant consists of several complex hydrotechnical works. The main one is the dam with stones and a clay core, which has 165 m high and 500 m long. There are observed active landslides in the lakeshores of hydroelectric power plants, which represent a great geological risk at Porava village, about 2.5km from the dam (Fig. 2, photo 1). Buildings have been destroyed in some villages and some people died in ruins. This phenomenon has been more evidently activated when hydrotechnical works started to be used. During the exploitation period of more than 25 years, the huge hydrotechnical works influenced the physical-mechanical properties in the shore area and caused a series of landslides. According to geological data, gathered during the design period, Porava landslide has a slipping mass of about 34 million m^3.

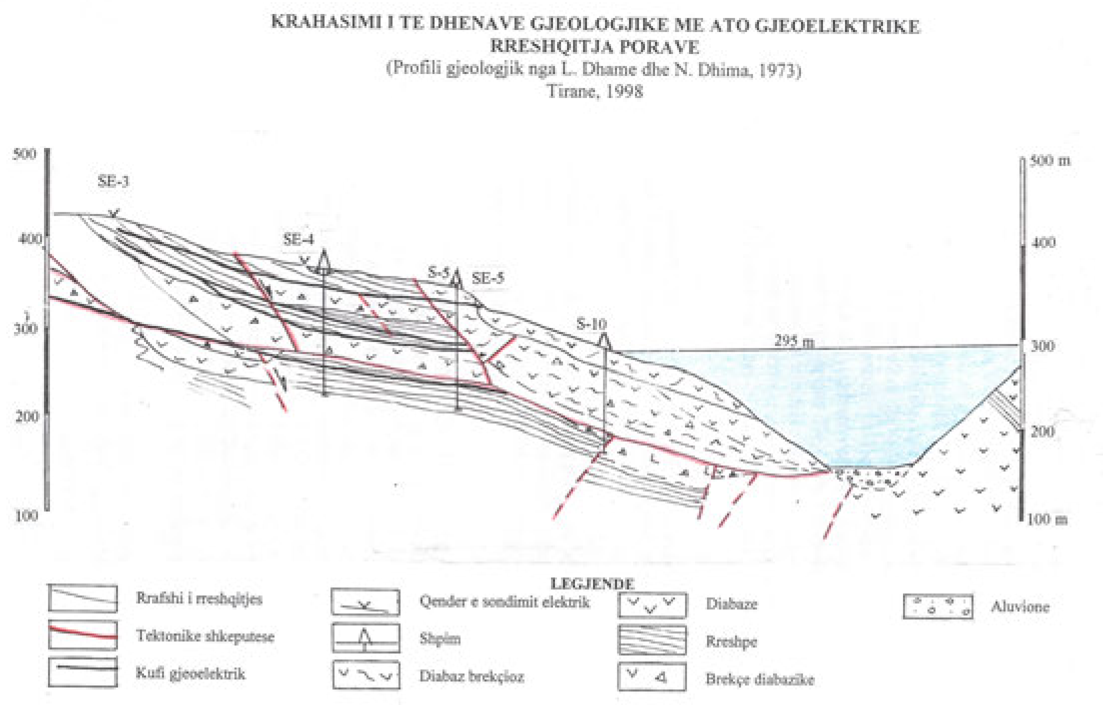
Special attention has been paid, since the projection period of this study, to the big slides in the shores of the Fierza Lake, especially to the Porava one (Fig. 3). The studies have not only included the geological understanding of the shore's solidity but also the understanding of the landslides. They also include solidity-integrated calculations through the hydraulics patterns. For that, the body fall of the Porava landslide at different speeds (from 5-10 m/sec) was simulated. As calculating parameters were used the ones resulted from geological studies of that time. All those studies brought to the conclusion that the dike should be

Drini River Basin
Ragami and Porava Landslides location (Scale 1:300 000)

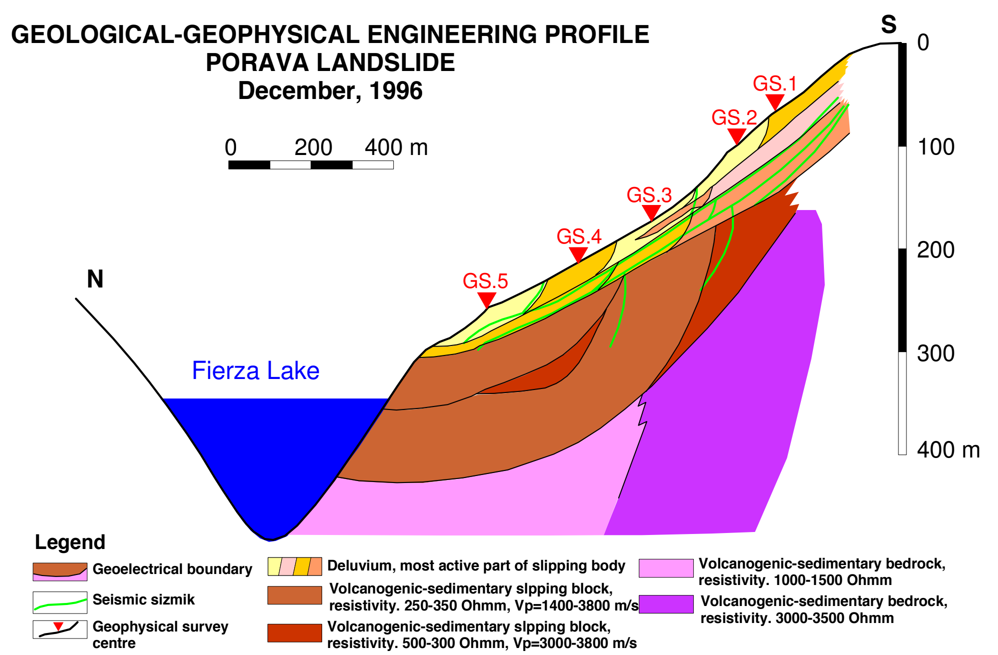


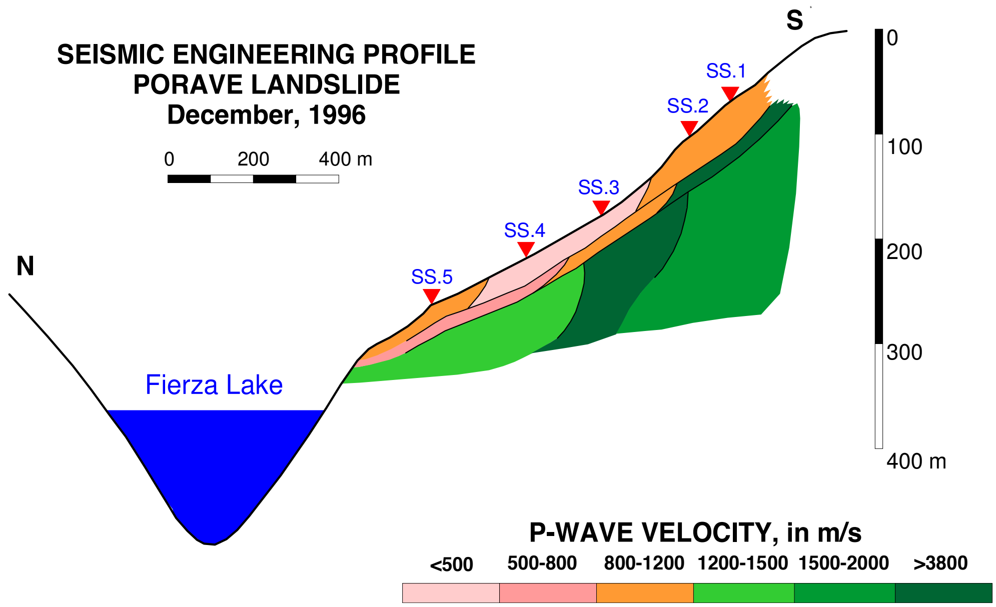
Porava Landslide area (Scale 1:25000)

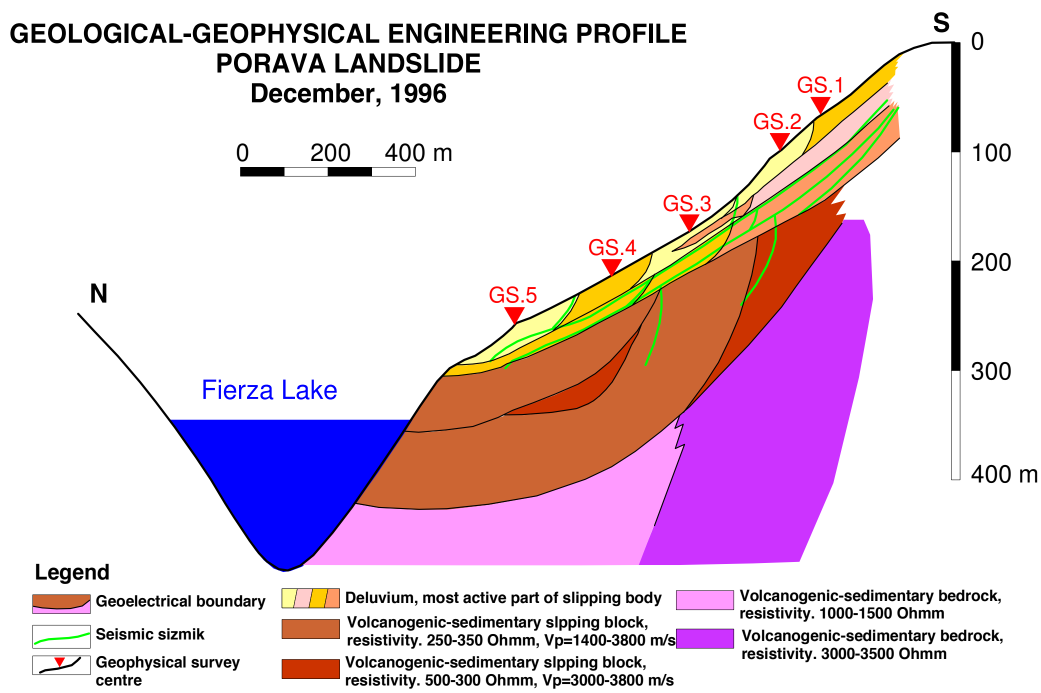
Cracks of the village houses walls



Geological (1074) and geoelectrical (1996) data comparison.




SEISMIC ENGINEERING PROFILE
PORAVE LANDSLIDE
December, 1996
0 200 400 m
N
S
SS.1
SS.2
SS.3
SS.4
SS.5
Fierza Lake
0
100
200
300
400 m
P-WAVE VELOCITY, in m/s
<500
500-800
800-1200
1200-1500
1500-2000
>3800


GEOLOGICAL-GEOPHYSICAL ENGINEERING PROFILE
PORAVA LANDSLIDE
December, 1996
0 200 400 m
N
S
GS.1
GS.2
GS.3
GS.4
GS.5
Fierza Lake
0
100
200
300
400 m
Legend
Geoelectrical boundary
Seismic sizmik
Geophysical survey centre
Deluvium, most active part of slipping body
Volcanogenic-sedimentary slpping block, resistivity. 250-350 Ohmm, Vp=1400-3800 m/s
Volcanogenic-sedimentary slpping block, resistivity. 500-300 Ohmm, Vp=3000-3800 m/s
Volcanogenic-sedimentary bedrock, resistivity. 1000-1500 Ohmm
Volcanogenic-sedimentary bedrock, resistivity. 3000-3500 Ohmm

raised 12 more meters over the one initially determined in the project, so that it would be more secure.

Today, based on the data generated from geophysical surveys, the geological knowledge about this zone and the visual study of the actual situation of the Porava landslide, it was realized the respective analysis of these integrated geophysical works.

In Fig. 4 is presented the detailed geoelectrical - engineering section. This section was compiled based on the date of the vertical electrical soundings. In that can be noticed the presence of the very heterogeneous electrical medium in strike and depth. There are two categories of geoelectrical borders in the profile. These are the primary borders, connected with the separation of the main zones of the slipping body (with that of the deepest plains 140-160 m deep and with that of the most superficial plane 20 m deep). These slipping plains have very different geoelectrical characteristics, because they have different geological properties. The second category belongs to the secondary geoelectrical borders, which clearly express the changes and the heterogeneity that exists in these two slipping planes and in the environment under them.

First of all, in these geoelectrical markers is expressed the full configuration of the sliding structure in the rocks of the volcanogenic sedimentary section. As a result of the slipping phenomena, these rocks have low, up to medium specific electric resistivity values (200 - 100 Ohmm). While the rocks located under the whole massive slipping body have higher specific electric resistivity values (in the furthest sector of the profile in the lake side 3000 - 3800 Ohmm and 1200 - 1400 Ohm in the sector located near the artificial lake of the Fierza hydropower plant).

The most upper part of this slide's body, represented by the deluvial-eluvial deposits, is very active today and has very law specific electric resistivity values (120 - 500 Ohmm). Houses and other objects of the Porava district are constantly damaged by this activity.

The apparent geoelectrical heterogeneity in the strike of the profile, expresses the block kind composition that has in general this slide and it also gives an envision of the development of this slide in time.

In fig. 5 is presented the seismic-engineering section in the same profile with the geoelectrical one. In this figure can be distinguished very well the upper part of the slipping body (the zone 25 m deep). In this section are very well distinguished the two seismic parameters (in the speed of the longitudinal and cross waves). The deluvial deposits have been fixed with V_p = 400 - 1200 m/s and V_s = 150 - 450 m/s values, while the eluvial deposits and the volcanic rocks of the most upper part, located over the slipped plane have V_p = 800 - 3880 m/s and V_s = 350 - 800 m/s values. The volcanic deposits located below the first slipping plain have been fixed with V_p = 1400 - 3800 m/s and V_s = 600 - 1500 m/s.

Based on the seismic parameters, the evaluation of the physical - mechanical characteristics of the rocks of this sliding body was carried out in strike and depth. In this seismic section and in the geoelectrical one, can be seen the block kind nature of the upper part of the slipping body and also of the lower part of this body in the basement volcanic rocks.

By studying the natural seismic-acoustic activity, different recordings can be noticed in all the surveying zones. This shows that the sliding activity is different for different parts of the slipping body. The most dynamic zones of this sliding massif are located in places where the micro - movements have maximum intensity values. The Porava village is located in one of these zones. Because of this activity, many houses, and the soil is damaged and slopes have moved about 2 - 4 m within a 2 - 3 years period of time (1994 - 1996)(Photo 2, 3).

In the detailed and integrated geophysical - engineering section, can be noticed a concordance between the electrical sounding results and the seismic surveying ones, used for studying this slide. (Fig. 6).

Also, in this section can be determined sliding plains, their nature, situation and the content of the two parts of the slipping body. The most upper part is made of deluvial-eluvial deposits and reaches up to 20 m deep, above the first most dynamic plain of this zone. Under this lays the volcanic rock massif, located over the deeper plane of the Porava landslide (100- 160 m). This plain is determined and separates the block like sliding body from the volcanic rocks, which have not been touched by this sliding activity.

Based on the results of this integrated geophysical-engineering and geotechnical study result:

1. There could not happened an immediate fall at any speed of the Porava slipping body.

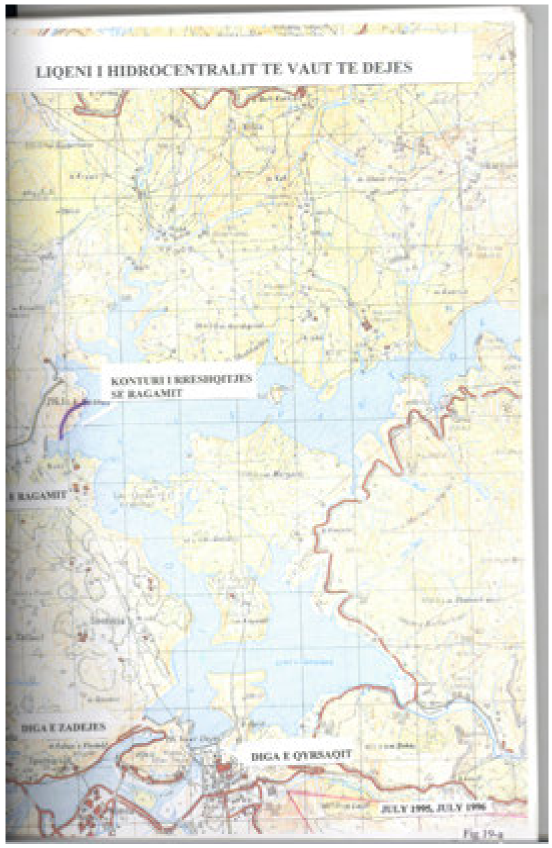
2. Even in cases of powerful earthquakes, the slipping body mass can not fall as a whole, because it is made of broken up block masses. It can fall parts by parts or in fragments. Natural or inductive earthquakes of normal intensity, which happen often in this region, till now have not caused massive detachments of the slipping body.

1.2.1.2. The Ragami Lanslide

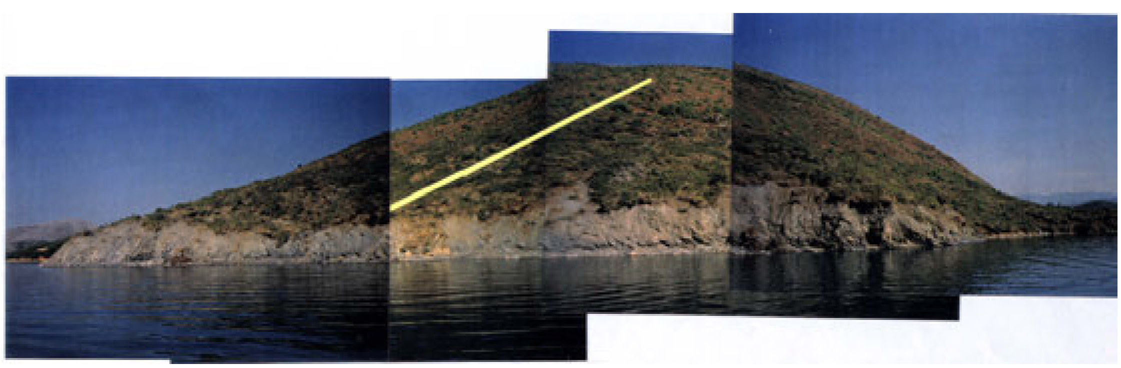
The typical landslide was developed at lakeshore of the Vau Dejes Lake of Hydropower Plant in Northwestern Albania (Fig. 7). It is developed in the ophiolitic formation represented by serpentinized rocks. The slipping body represents a big mass of serpentinite, which is eolated, destroyed and covered by a thin layer of deluvium. According to the geological survey in 1992, the landslide did not exist. Landslide has been significantly developed during the last ten years (Fig. 8). The yearly movements of water level at Vau Dejes Lake caused a big landslide at eolated, weathered and destroyed serpentine rocks. Slipping body increased in the extent and in the volume substantially during this period. The front part of the slipping body is located along the shores of the lake. This part has the shape of a scarp about 2 -3 m high, and represents a destroyed, schistose serpentinite, partly in a form of mylonite (Photo 4, 5).

In fig. 9, 10 are given the integrated geophysical - engineering sections of the slipping body. Two main sliding plains separate this body. These plains are broken up. The first plain is at depths of 5 - 7 m, while the second one reaches up to 22 m. The lowest part of the second plain touches the lake, under the water level. In this way, the sliding body has a block like

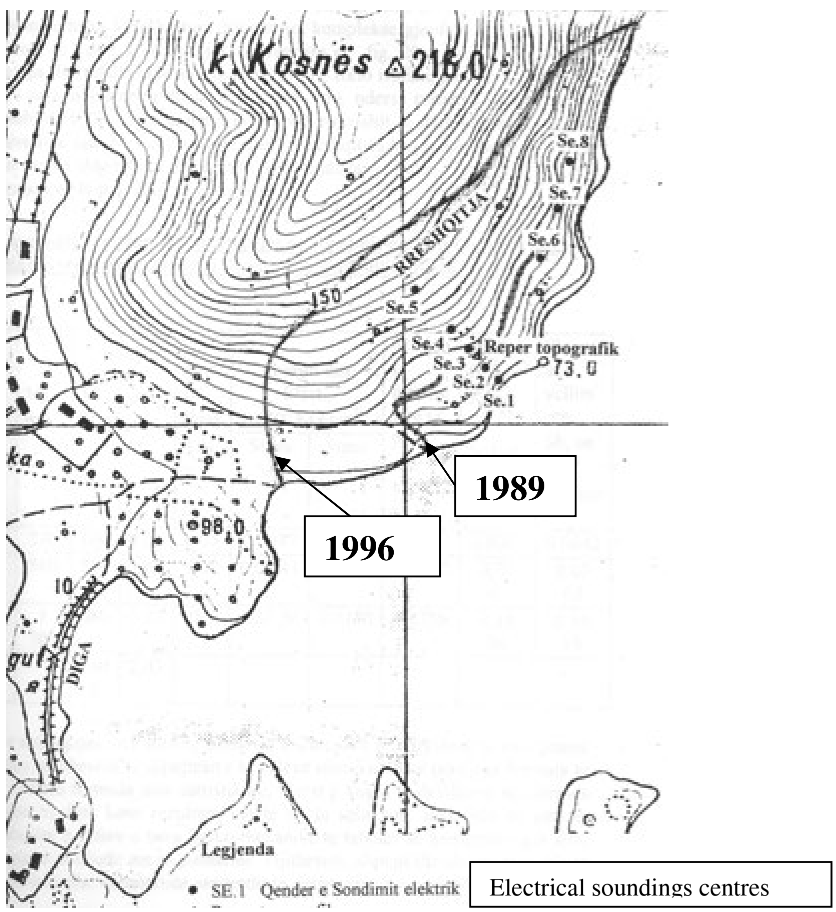
nature. The physical - mechanical properties of the rock massif of the slipping body are lower than those of the basement rocks, not touched by the sliding phenomena. The micro movements in the slipping body are very intensive and have a wide frequency band, while outside the body there is no such activity (Fig. 11).



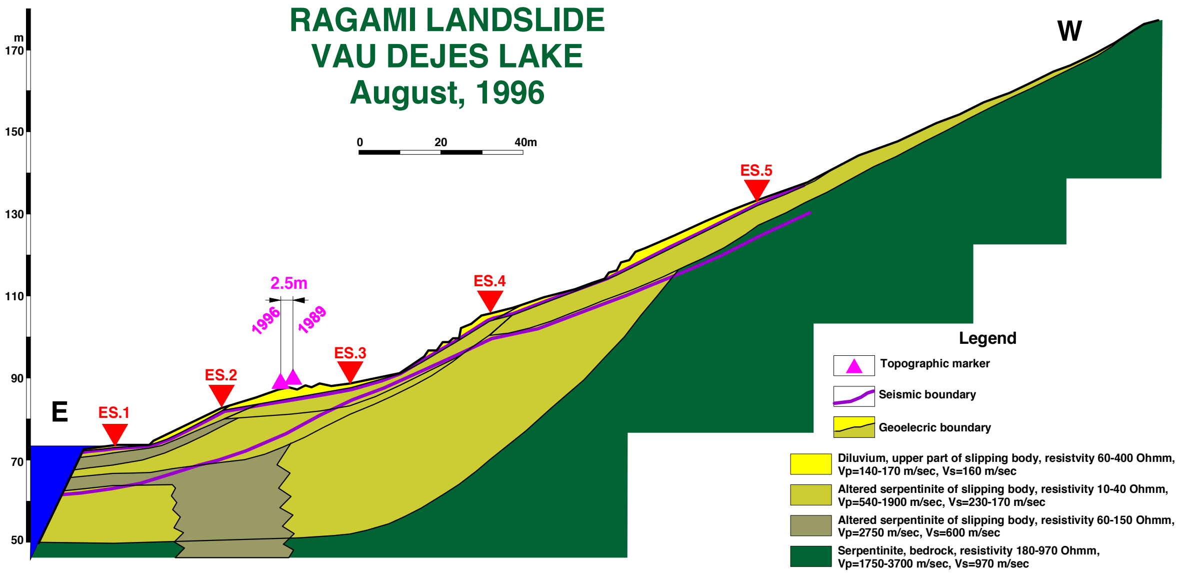
Vau Dejes area and Ragami Landslide



Ragami landslide body, mylonite serpentinites

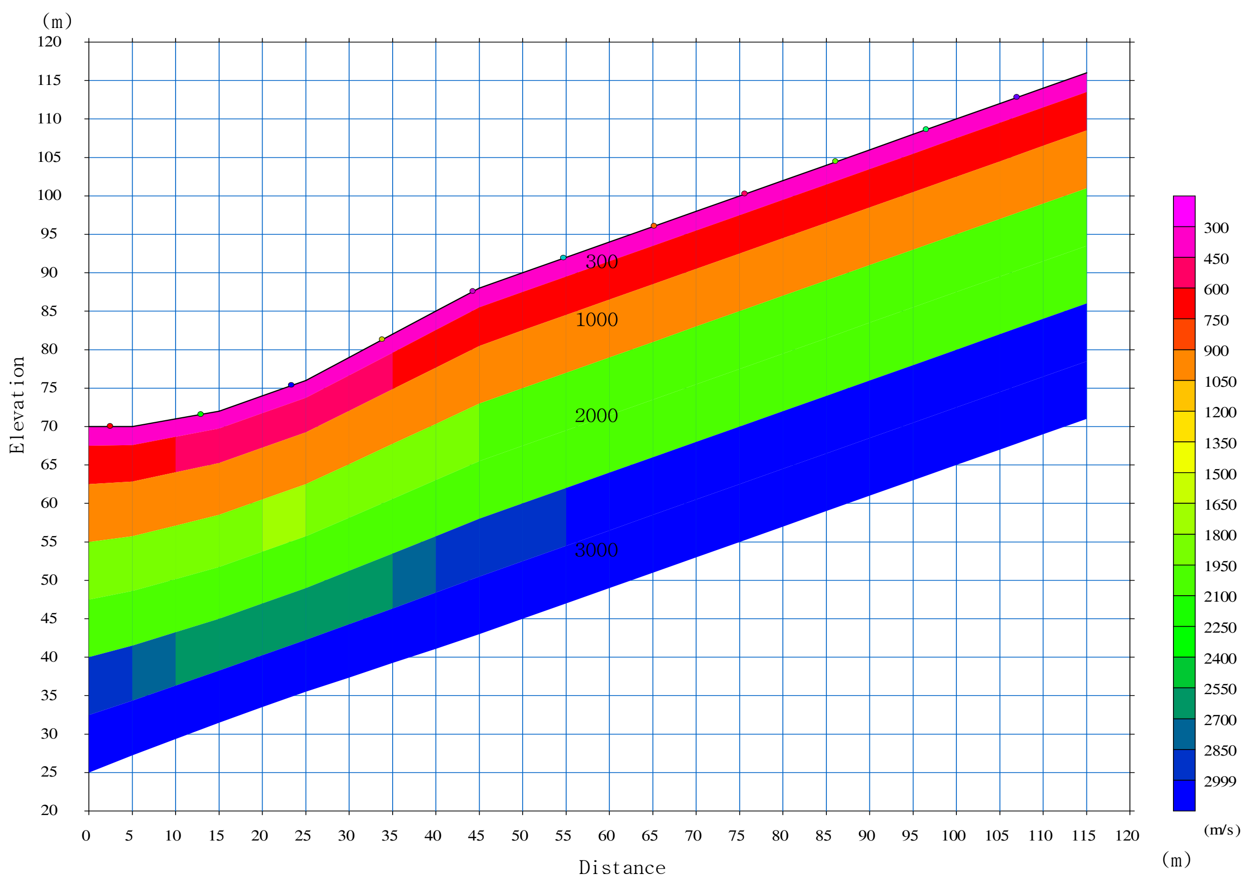


Topographical sketch of Ragami Landslide area
1989; 1996- Landslide body contours, respectively .



Transversal profile

The longitudinal waves velocity Vp, the layer thickness are calculated from the field data are presented in the profile. Several continuous iterations have been applied during the data processing until the detailed seismic velocity model obtained across the lithological layers at depth.



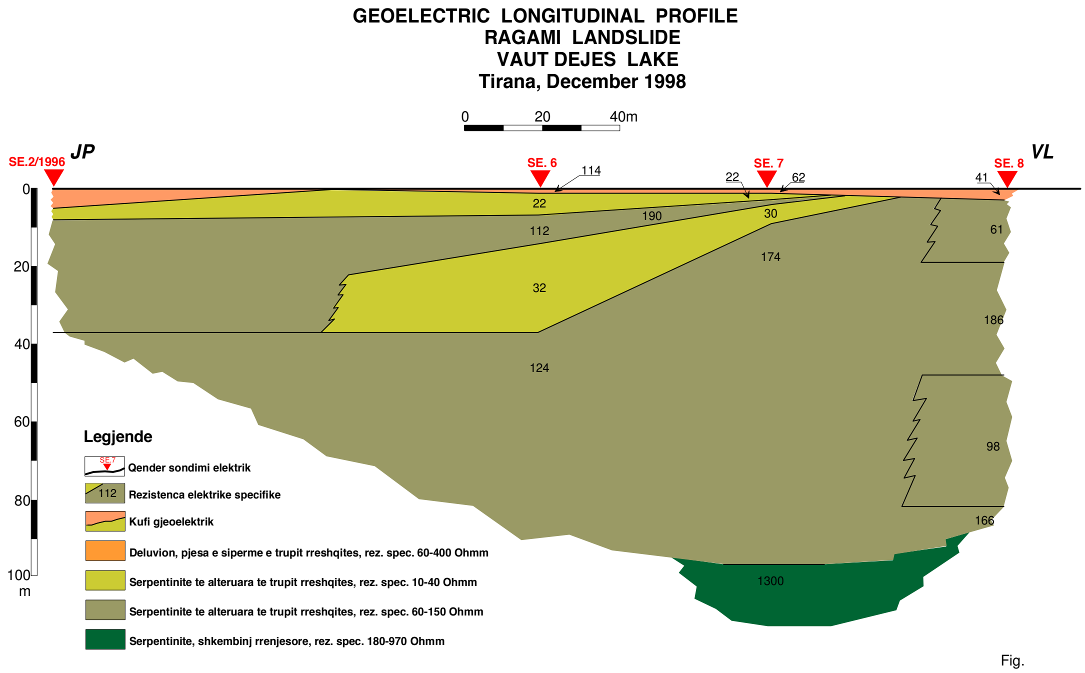


Fig. 7. Engineering integrated geophysical section of the Ragami landslide.

Three failures in different superficial levels can be observed in this landslide:

- The first one 35 - 45 m from the shore, with a horizontal dislocation of about 2 m.
- The second one about 70 - 90 m from the shore, with a vertical jump of about 2 m.
- The third one about 115 - 130 m from the shore. This is the newest level and has the lowest amplitude.

The physical-mechanical properties of the slipping body are lower than those of the basement rocks, not touched by the sliding phenomena.

Physical-mechanical properties of rocks in the area of Ragami Landslide are presented in Tables 1 and 2.

Tab. 1

PHYSICAL PROPERTIES IN LANDSLIDE'S AREA

Layer Number	Thick-ness, in meters	Resistivity in Ohmm	Density, in g/cm^3	Wave Velocity, in m/sec		Lithology
				Vp	Vs	
SLIPPING BODY						
1	0.7	76.4	1.34	210	160	Deluvium
2	4.0	29.5	1.61	540	230	Breaking serpentinite
3	6.5	46.5	2.45	3700	680	Water-bearing serpenti-nite,
4	17.4			1500		Breaking serpenti-nite
BED ROCKS						
		485	2.56	3500	1920	Serpenti-nite

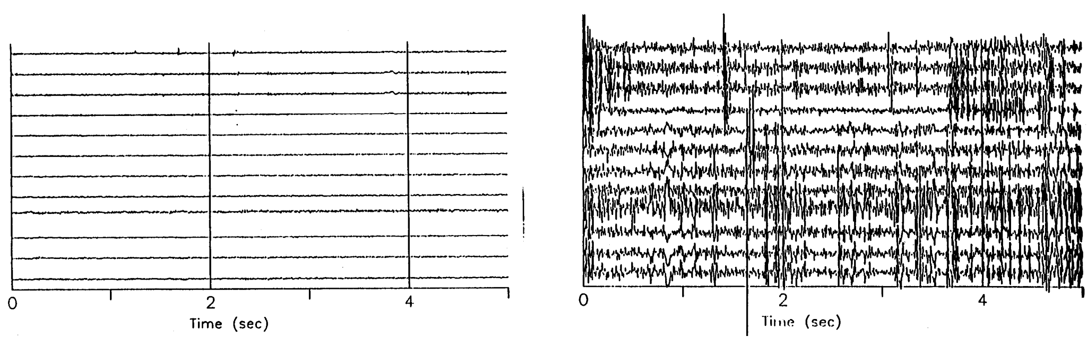
Tab. 2

. MECHANICAL PROPERTIES IN LANDSLIDE'S AREA

Layer Number	Poisson's Ratio	Dynamic Modulus of Elasticity, E_d^s in $*10^5$ kg/cm^2	Rigidity Modulus G, in $*10^5$ kg/cm^2	Volume Compression, σ, in $*10^5$ kg/cm^2	**Rock state**
SLIPPING BODY					
1	0.35	0.00370	0.00140	0.00420	soft rocks
2	0.39	0.02413	0.00868	0.03630	Destroyed, shattered rocks
3	0.48	0.56586	0.19167	3.26503	Cleavages and fissured rocks
4		0.26325	0.09608		Destroyed, shattered rocks
BED ROCKS					
	0.29	2.46271	0.96199	1.91408	Compact rocks

As documented in Tables 1 and 2, four layers with different physical-mechanical properties create the slipping body. First layer represents the deluvial cover. Layers 2 and 4 are represented by destroyed-shattered serpentinite. The third layer in between is characterized by low electrical resistivity and low shear waves velocity. It corresponds to the water saturated cleavages and fissures in the serpentinite.

The dynamics of slope movement is also reflected in the natural seismic-acoustic activity. The micro-movements in the slipping body are very intensive and have a wide frequency band. No movement activity is observed outside the slipping body (Fig. 11).



Outside of slipping body — Inside of slipping body

Fig. 8. Natural seismic-acoustic activity in the Ragami landslide area

After the analyze of geophysical investigations in Ragami landslide, have been concluded:

1. Thick and high volume slipping bodies represent the Ragami active landslide in the shore area of the Vau Dejes Lake.
2. The extent of the landslide and the position of sliding plains were precisely fixed using the integrated geophysical survey.

3. The block-like character of the sliding bodies brings to the conclusion that the block of these bodies can not fall down immediately in any kind of velocity.

1.2.3. Landslide in the Oligocene flysch formation.

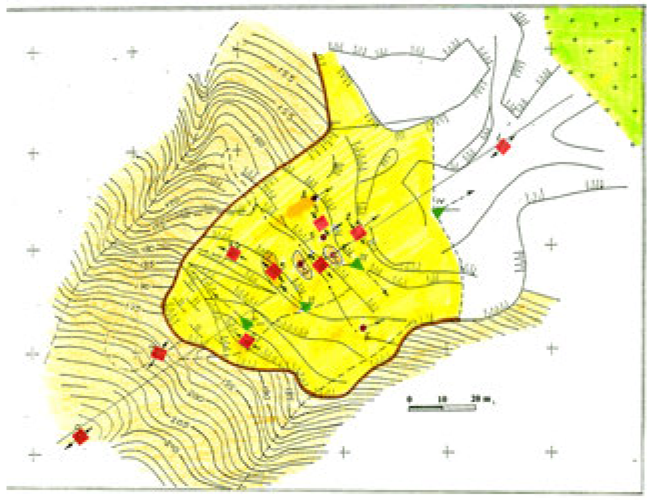
There are instable mountain and hill slopes, slipping of rocks masses, sometime of great sizes and catastrophic results. In some cases even villages or parts of villages were destructed, as Guri Zi in Elbasani region, Moglica in Devolli River region, Gjyras in Maliqi region etc., and without mentioning the blockage of auto-roads and railways.

1.2.3.1. The Banja Landslide

This slide was created when the derivation tunnel of the Banja hydropower plant was dug. It was developed during drilling in the flysch formations of Paleogene (Fig. 12, photo 6). The high content of thick sandstone layers, dipping according to the relief, is very characteristic for the flych section. This landslide completely ruined the derivation tunnel built till that time.

In fig. 13 is given the integrated geophysical - engineering section along the Banja slipping body. The maximum depth of the strike of the sliding mass is 22 m (in the center of the profile). The geoelectrical characteristics of the slipping body are very distinguishable from those of the flysch formation located outside the slide. The same thing is for the spreading velocity of seismic waves. The slipping body is very heterogeneous and is made of different blocks.

SKEME TOPOGRAFIKE E RRESHQITJES SE BANJES
Shkalla 1: 1 000



LEGJENDE

- Konturi i trupit te rreshqitjes
- Shkembinjte rrenjesore, flish
- Reper gjeodezik
- Qender e sondimit elektrik
- Qender e vrojtimit sizmik
- **Dige**

Sketch of Banja landside area

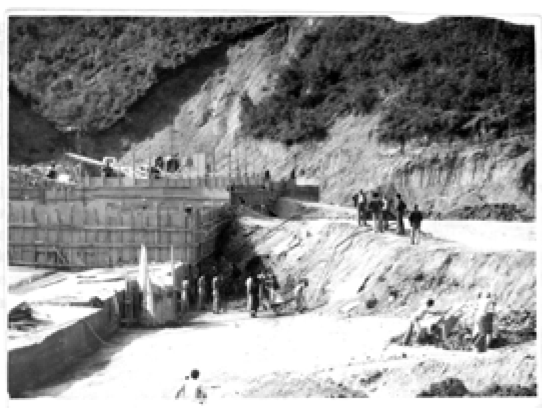
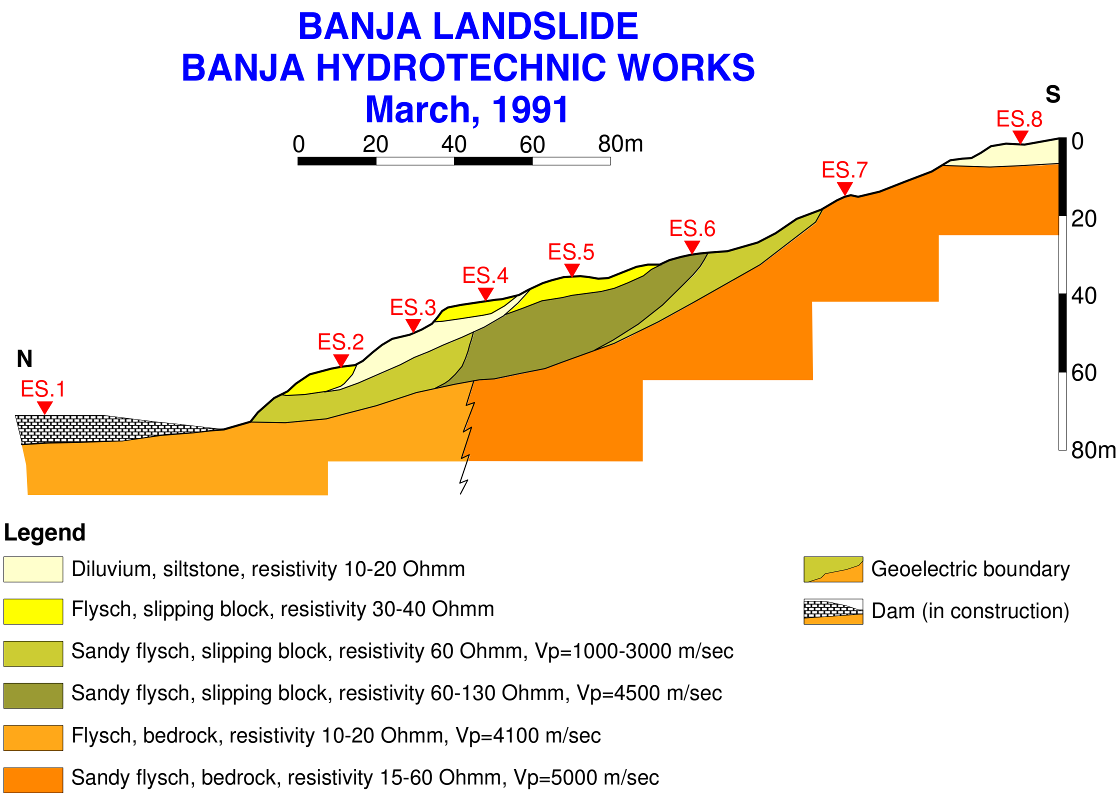


Foto 15. Pamje nga rreshqitja ne vepren hidroteknike te Banjes (Korrik 1987).

Banja Landslide area


BANJA LANDSLIDE
BANJA HYDROTECHNIC WORKS
March, 1991
0 20 40 60 80m
N
S
ES.1
ES.2
ES.3
ES.4
ES.5
ES.6
ES.7
ES.8
0
20
40
60
80m
Legend
Diluvium, siltstone, resistivity 10-20 Ohmm
Flysch, slipping block, resistivity 30-40 Ohmm
Sandy flysch, slipping block, resistivity 60 Ohmm, Vp=1000-3000 m/sec
Sandy flysch, slipping block, resistivity 60-130 Ohmm, Vp=4500 m/sec
Flysch, bedrock, resistivity 10-20 Ohmm, Vp=4100 m/sec
Sandy flysch, bedrock, resistivity 15-60 Ohmm, Vp=5000 m/sec
Geoelectric boundary
Dam (in construction)

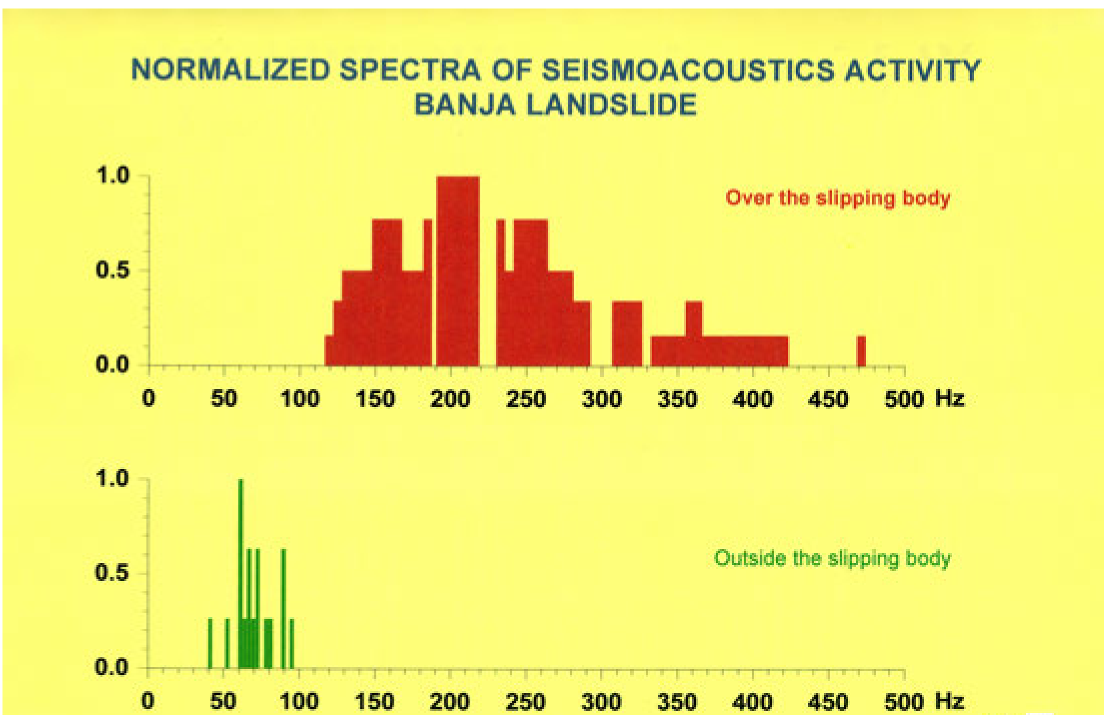

NORMALIZED SPECTRA OF SEISMOACOUSTICS ACTIVITY
BANJA LANDSLIDE
1.0
0.5
0.0
0 50 100 150 200 250 300 350 400 450 500 Hz
Over the slipping body
1.0
0.5
0.0
0 50 100 150 200 250 300 350 400 450 500 Hz
Outside the slipping body

Fig. 15

This slide was characterized by a very intensive dynamic of the movement of the sliding body mass. For about one month, a sliding mass of 17 000 m^3 was displaced about 5 - 7 m, according to geodesic markers. This dynamic is also expressed in the natural sismoacustic activity. Inside the sliding body predominate higher frequencies than outside it (Fig. 14). The micro - movements have an amplitude many times higher.

1.2.3.2. Guri Zi village landslide

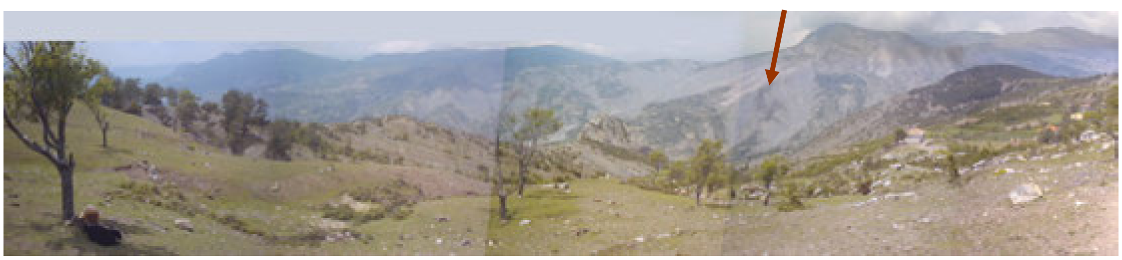
Guri Zi village is located about 12 km north-east of Elbasani city, at the upper stream of Zaranika River. Oligocene flysch formation is extended in this mountain area (Fig. 12, 16). At the Guri Zi village and its environment area is located intersection of the regional transversal fault Vlore-Elbasan-Diber and western thrust tectonic of the Krujas tectonik zone. This area represents a part of very seismically active Elbasani zone, with the earthquakes intensity 9 balls MSK-64. Geological setting, very intensive seismological activity in the past, hydrological regime of the mountain's streams, have created the unstable slops and landslide development, with gigantic sliding body (photo 7, 8).

GEOLOGCAL MAP OF ELBASANI AREA

TOPOGRAPHICAL MAP OF ELBASANI AREA
(Scanned after 1:300 000 scale)

1063

Topographical Map of Elbasani area (scanned after 1:100 000 scale)

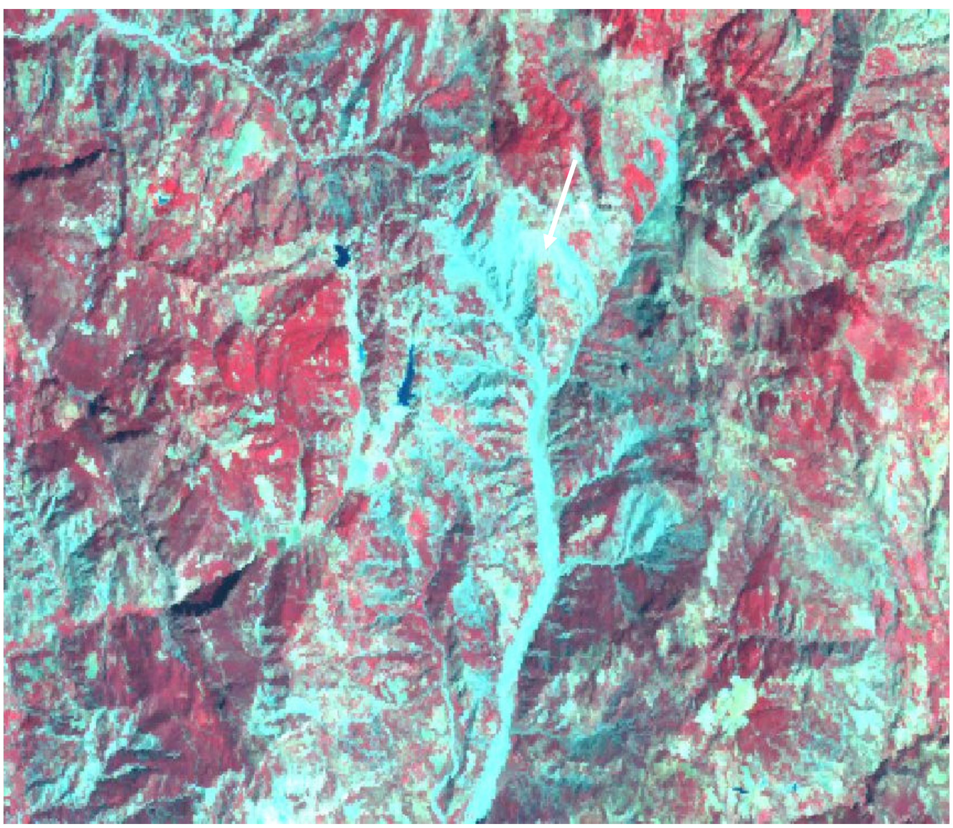


Guri Zi Landslide area

TM Image 1986 c AWAP

Processing by Ismail Hoxha, 2004

Guri Zi Landslide area



1.2.3.3. Moglica and Gjyrasi village landslides

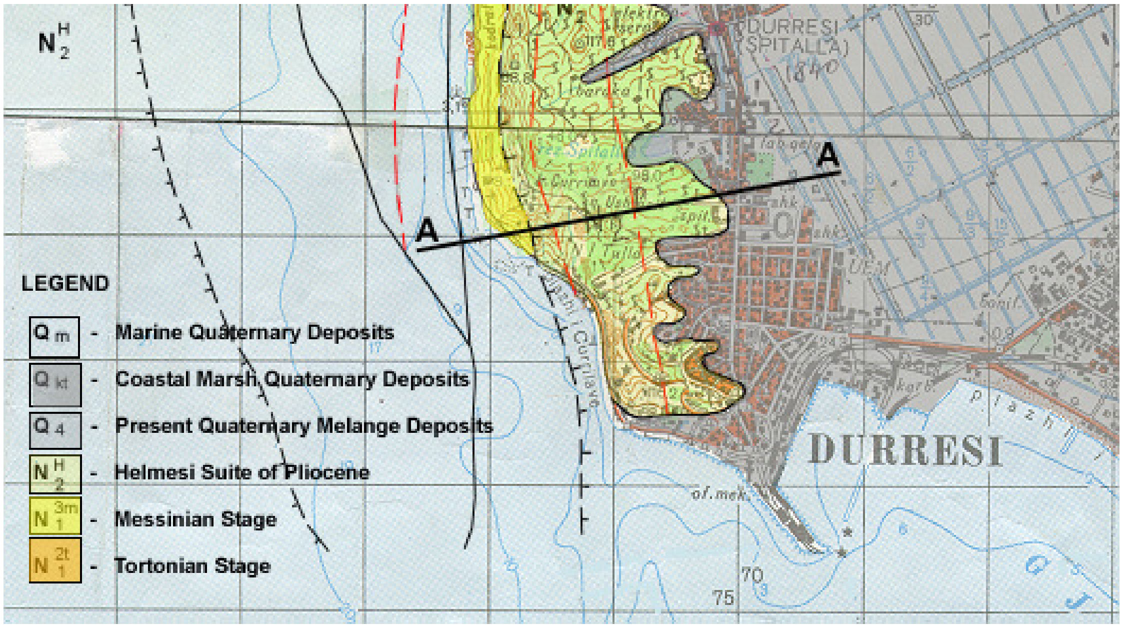
1.2.4. Landslide in the Neogene's molasses formations.

Landslides in the Neogene's molasses are located in several Albanian zones, with different sliding body mass.

1.2.4.1. Durresi landslide

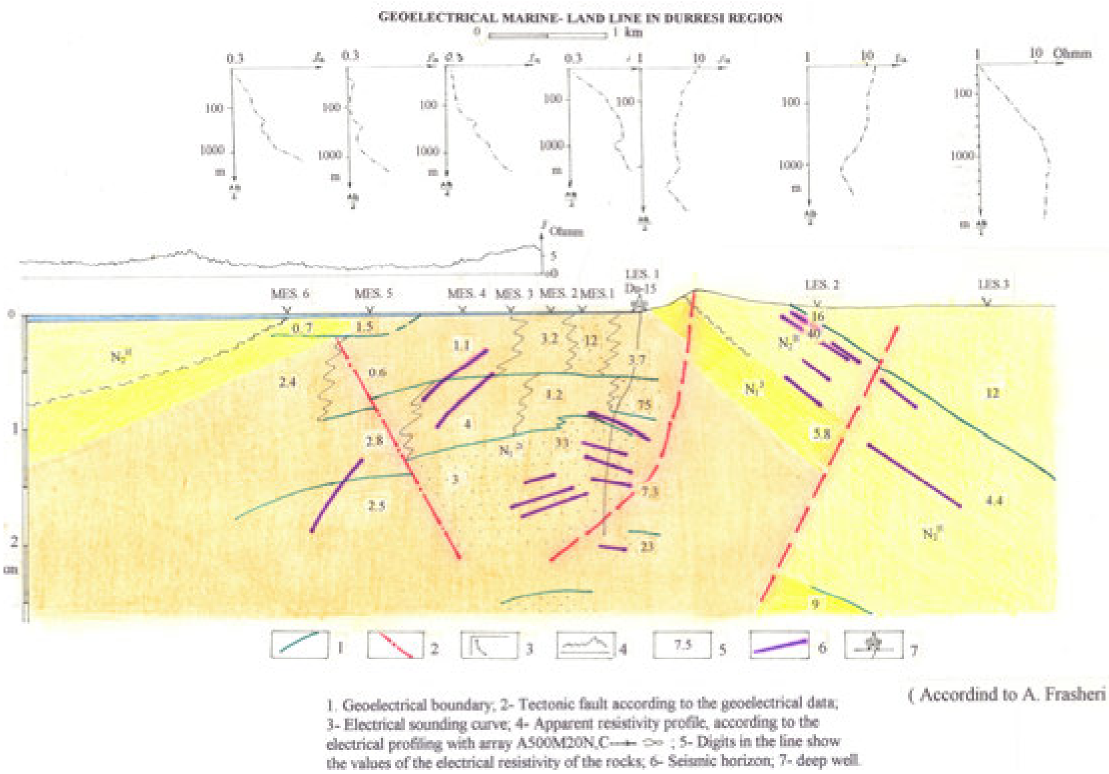
Durrësi city area is characterized by a presence of neogene molasses formation: (Frashëri A. 1987, Hyseni A., et al, 1976, 1986, Leci V. et al. 1986): sandstone-clay Tortonian deposits, clay, sandstone interbeds and lens, and gypsum debris and blocks Messinian deposits, and silty clay of. Pliocene Helmesi Suite (N_2^H). Durrës structure is asymmetric top part of the big anticline. Western anticline limb has a dipping about 20-30°. Eastern flank is tectonically abrupt and has a dipping 45-55°. Top Durresi anticline is located about 1600 m at the west of the coastal line. Part of Durresi city is located over the Neogene's molasses hills (Photo 9). The Pliocene clay slope at southern part of the Durresi hills is unstable. There the big landslide activity is observed (photo 10). Over this slope have been constructed many buildings. Actually, in several buildings have observed wide wall craks.

Durresi City and landslide location



Geological Map of Durresi area

Profile A-A



(a) **(b)**

Wievs of Durresi Hill, Northern Slope (a), Southern Slope (b)

Landslide

Durresi Landslide

Subsidence of the villa wall, caused by landslide

Cracks in the villa walls and transversaly of the road

1.2.4.2. Krraba landslide

1.2.4.3. Landslide in irrigation reservoir at Vuno village.

Landslide in the irrigation reservoir in the Vuno village has been activated during the drawing, caused by mechanical suffusion from augmentation of the hydraulic gradient at the reservoir slopes.

Geological setting of the reservoir area is presented by overburden bed, composed by mylonite breccia in the allochtone tectonized belt of the Upper Jurassic carbonate layers and calcareous slate, which have been dislocated by gravity tectonics, over the terrigenous formation. Overburden deposits are classificated as coarse and granule sand with cohesion θ=0.1 kg/cm2 and fraction composition:

Fraction >2mm	30-28%
2-0.05 mm	24-39%
0.05-0.002 mm	15-21
<0.002 mm	0-12%

Unrounded clastic chert and limestone mater composes granule sand fractions.

Electrical soundings, located at two profiles over the landslide body, have carried out by Schlumberger array, with a current electrode maximal spacing AB/2=150m (fig. 1). At fig. 2 Is presented the geoelectrical profile. First geoelectrical layer represents sliding body, with a thickness 10m. Overburden deposits compose landslide body with a resistivity 50 Ohmm. Second layer is composed by plastic and soft clay deposits with lower resistivity (1.2-50)Ohmm, cohesion θ=0.12 kg/cm^2, internal scouring angle 11^o, and thickness 4m. This layer represents slickenside. Lower geoelectrical layer has higher a resistivity (200-

750)Ohmm, which is represented by elluvial sand and argilloite, carbonate mylonite and tectonics breccia, and several limestone blocks with higher resistivity (2600-4500)Ohmm.

Borehole has very good verified electrical soundings interpretation. Electrical well logging, by a B0.1A0.95M has very detailed selected all layers. After laboratory analysis of the samples has been observed that landslide body deposits and bedrocks have different physical-mechanical properties: respectively volume weight 1.71 g/cm^3 and (1.83-1.95)g/cm^3, porosity 57.3% and (34.7-46.4)%, natural rock moisture 33.4% and (28.3-29.8)%.

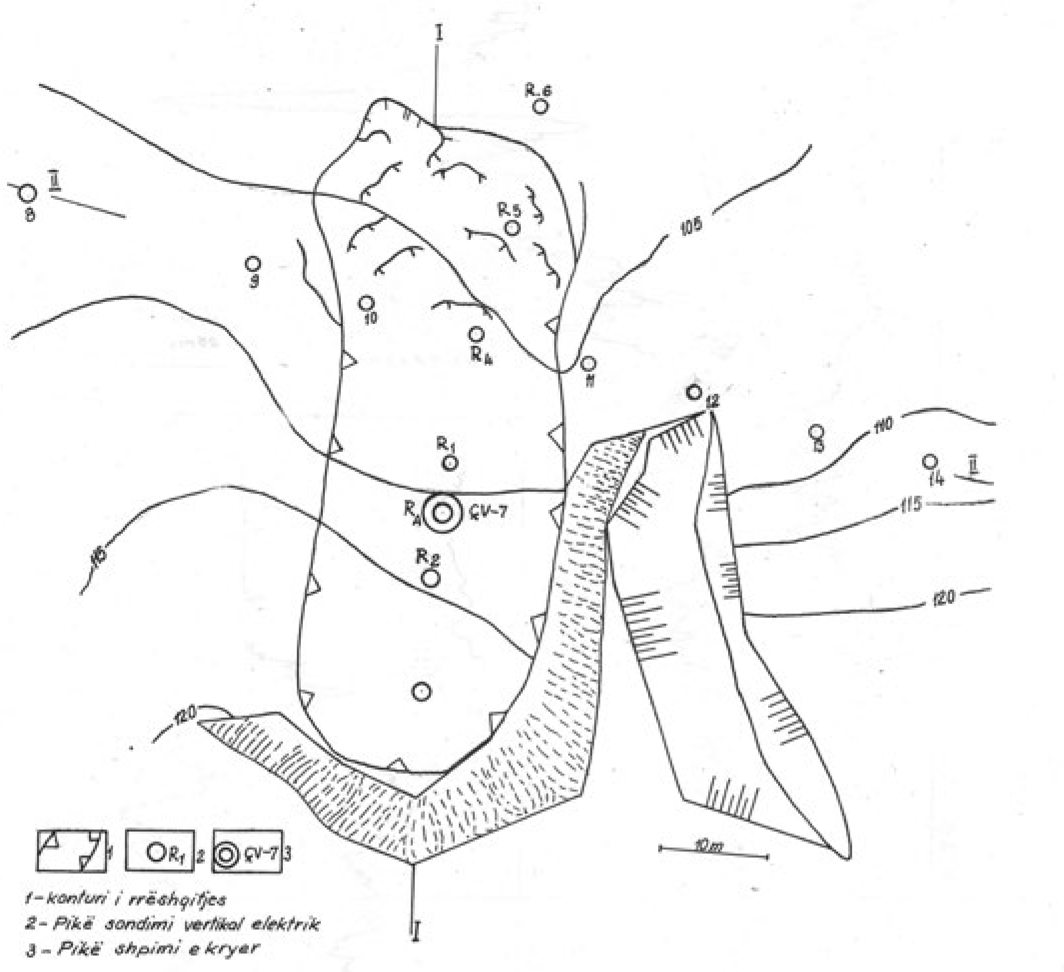


Fig. 1. Vuno landslide topographic sketch

1- Landslide contour
2- Eletcrical sounding centre
3- Borehole

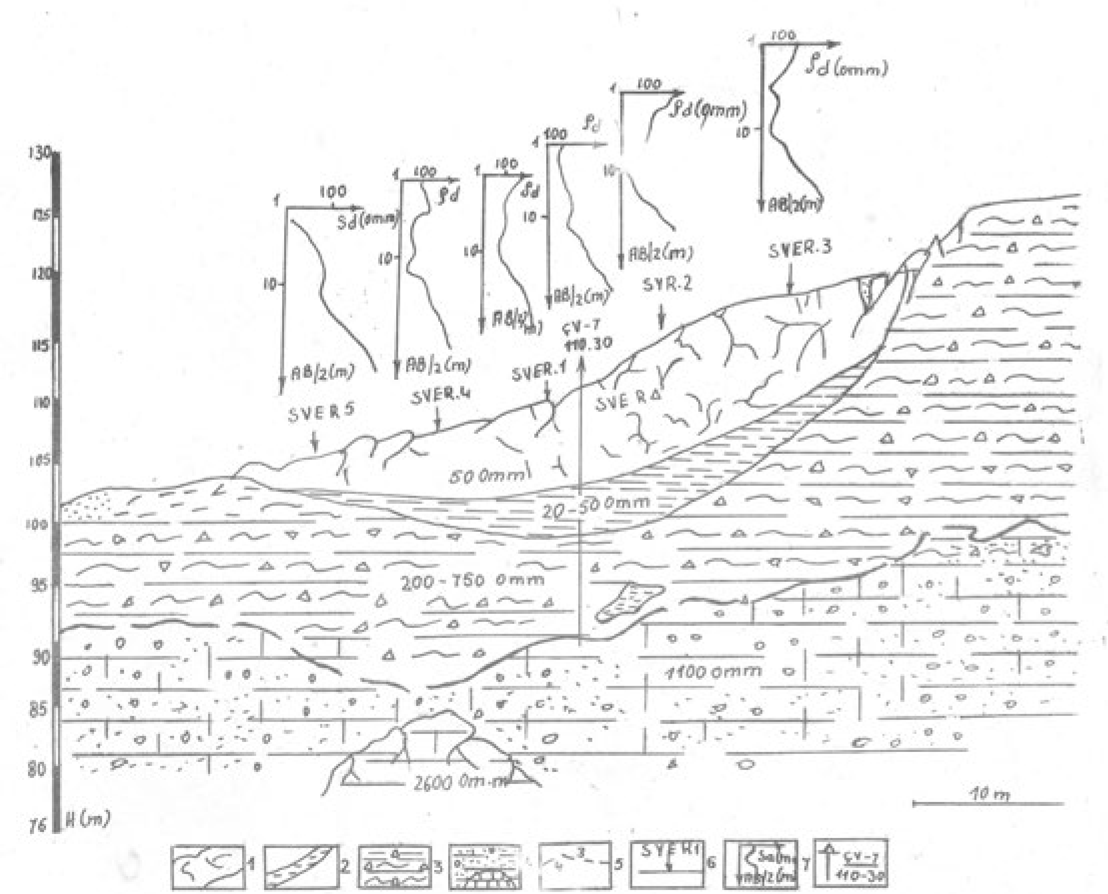


Fig. 2. Geoelectrical section, Vuno landslide

1- Sliding body; 2- Slickenside bed; 3- Overburden bed; 4- Mylonite and tectonized breccia of thin layered limestone; 5- Lithological boundary; 6- Electrical sounding centre; 7- Apparent resistivity curve of electrical soundings; 8-Borehole.

1.2.5. Downfalls in the weathered rocks

1.2.5.1. Kruja Castle

The Castle of Kruja is the symbol of the culture and Albanian history. This castle is related with the most glorious epoch of the Albanian National Hero Skanderbeg (Photo.11).

Kruja Castel

Downfalls in the Kruja hill

GEOPHYSICAL ENGINEERING SECTION
KRUJA CASTLE AREA
April, 1996

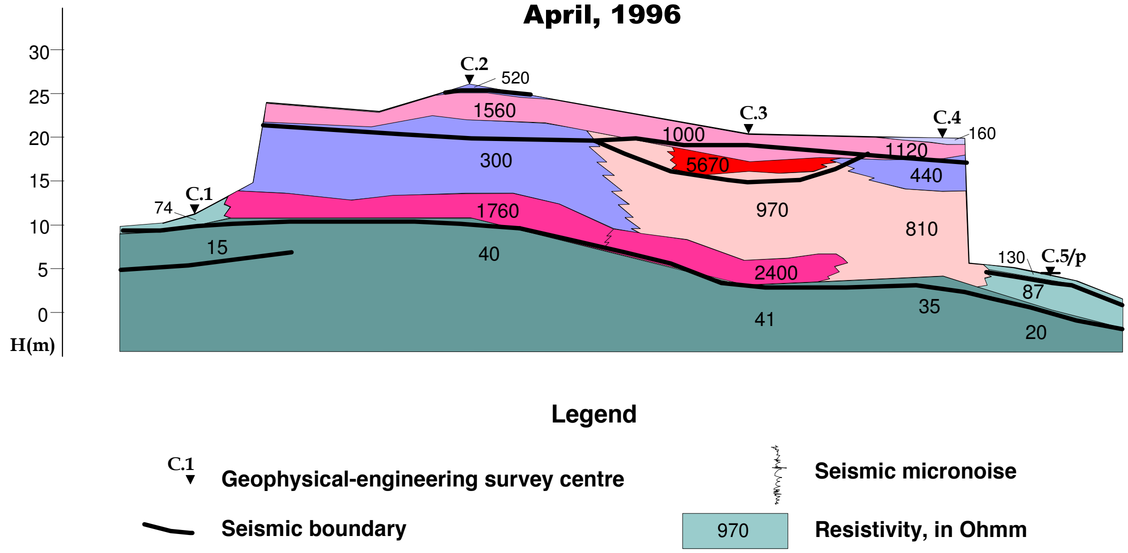


Fig. 2

Many excavations have been conducted up to present, aiming at bringing out the interior part of the Castle and the clock tower. The surrounding walls have been completed with a museum structure as the Museum of the National Hero, where every visitor gets acquainted with one of the most remarkable moments of the Albanian history. In 1995, the Castle, which was considered relatively safe, was "shaken up" under the Gjergj Kastrioti Skenderbeg Museum. The downfall occurred after a period of heavy rainfall, characterized by heavy showers and a rapid decrease of temperature. The overnight downfall of the large detached masses of about hundreds of cubic meters was unexpected. Now the ground has started to deteriorate and at the sides of the castle, in some places is developing a process of collapse. This is a well known phenomena for this Castle. The deterioration has also continued during 1996-1997 though the detached rocks have been smaller in size.

Geophysical surveys have been carried out for ground investigation. The results of the surveys are presented on the geoelectrical-geotechnical section (Fig.18). It can be seen on the section that the rock massive, where the Castle was constructed, is composed of breccia-conglomerate formation. The breccia-conglomerate formation onlaped on the Oligocenic flysch section. The upper part of the flysch section around the Castle is covered by deluvium, 1÷4 m thick. Under the deluvium lays the weathered layer. The breccia-conglomerate massive, where the castle was constructed, consists in 3-4 main layers, which, in extension have different thickness and are heterogeneous. The layer that attracts the attention more is the third geoelectrical layer, which is located at a depth of 3-24 m. Its resistivity varies between 300-900 Ohmm, which is significantly less than those lying over and under that. This layer, generally is characterized also by smaller velocities of longitudinal and transversal seismic waves, which vary between V_{pl} = 500-1800 m/sec and Vs_1 = 400-830 m/sec, meanwhile the layers lying under it have a velocity of the range 2300-

3100 m/sec and 870-1050 m/sec respectively. The dynamic module of elasticity of the first seismic layer varies between the limits 390-1400 kg/cm^2, which apparently has a very low value. The statistical analysis of the samples of the volumetric mass resulted in a large distribution of this property. The minimum values vary from 2,12 g/cm^3 to a maximum of 2,45 g/cm^3. These indexes underline the fact that in the surveyed centers we are in the presence of a breccia-conglomerate layer heavily destroyed, containing a large quantity of saturated clay, though in a very weak state.

The observation of the natural seismic micro noises has shown that the breccia conglomerate rock massive has a noise level 2-8 folds higher than in the flysch profile touching along side this massive (Fig. 19). This shows that the systematic destruction of the massive is in a continuous process. Inside the rock massive, the seismic micro noises increase towards its outskirts.

4. Conclusions

Based on the above analyses can be reached the following conclusions:

6. In the profiles, where integrated geophysical surveys have been conducted, were fixed the bodies of the studied landslides. In these profiles were also clearly fixed the sliding plains. In general, even though the geological conditions in which these slides have been developed are different, the plains have regular configuration, with maximum deepness in the center of the profile.

7. The slipping body, very often, is made of several slipping plains of block like character. Especially active today, are the slipping plains located 15 - 20 m deep. The slipping body over this plain is mainly made of deluvial - eluvial sediments, or rocky masses with very weak physical - mechanical characteristics. Their dynamic is causing more damages every day to the houses of the Porava village.

8. The Porava landslide is the biggest slide studied till now. The lower plane of this landslide is located about 100 - 160 m deep. It separates the volcanogenic-sedimentary rocks with very low petrophysical characteristics from the volcanogenic-sedimentary deposits untouched by the sliding phenomena. The total volume of the whole sliding body, from some approximate calculation based on these preliminary geophysical data, is estimated to be over 40 million m^3.

9. The Porava slipping body is heterogeneous and composed of blocks.

10. The block like nature of the sliding bodies brings to the conclusion that in general these bodies can not fall immediately as a whole, in any kind of velocity. Only in particular cases, like in Banja, the fall occurs immediately.

11. The structure of the slipping body and its dynamic stands in the foundation of the patterning on the landslide development. Besides the others, the height of the dam is directly defined from this pattern. Accepting the slipping body as a unique mass, has sent to the over heightening of the dam and greater expenses.

12. Thick and high volume slipping bodies represent the Ragami active landslide in the shore area of the Vau Dejes Lake.
13. The extent of the landslide and the position of sliding plains were precisely fixed using the integrated geophysical survey.
14. The block-like character of the sliding bodies brings to the conclusion that the block of these bodies can not fall down immediately in any kind of velocity.

4. Geophysical-engineering studies have a triple character: a) to study the soil of the landslide area, b) evaluation of in-situ physical-mechanical properties of soils and rocks and c) in-situ monitoring of landslide phenomena.

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SPONSOR TIREX EXPLORATIONS SHPK

SOME SURVEY AND INTERPRETATION PROBLEMS ON IP METHOD

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Abstract

In the paper problems of IP mining exploration are analyzed and solutions presented. The dipole-dipole array configuration is considered as a symmetrical array in terms of the reciprocity principle. This paper demonstrates that the IP/Resistivity anomaly configurations depend on array geometry. The IP/Resistivity anomaly configuration observed with a C_1C_2 –P_1P_2 array is not the same as the one observed with a P_1P_2-C_1C_2 (reversed) array.

The inversion of IP pseudo-section of a dipole-dipole array survey is evaluated by resolution capability and stability of inversion solutions. The analysis presented in the paper, which is based on new data from mathematical and scale modeling of IP anomaly effect, as well as field survey results, presents also the necessity to taking into account aspects of non-linear IP phenomenon.

The analysis includes results of 2D and 3D mathematical and scale modeling performed in the Institute of Informatics and Applied Mathematics, and in the "Ligor Lubonja" Laboratory of Geophysics at the Faculty of Geology and Mining, Polytechnic University of Tirana and at the Geophysical Department, Albanian Geological Survey (Alikaj P. 1981, Frashëri A. et al. 1984, 1994, 1995, 2000).

Key words: Dipole-Dipole array, Reciprocity Principle, IP anomaly, Apparent Resistivity Anomaly, Inversion.

1. Introduction

In the practice of electrical prospecting surveys various array configurations are employed. The location of the current and potential electrodes is defined by the geological tasks to be solved. The dipole – dipole array is one of the most common arrays in mineral exploration. This is considered a symmetrical array in terms of the principle of reciprocity, so when the current electrodes are respectively switched to potential electrodes the same responses in IP and resistivity values would be observed. However, our recent mathematical and scale models

indicate discrepancies in this regard in several cases. This can lead to inaccurate target location and negative drilling results. To avoid such situations, the electrode orientation in the survey line has to be considered in the interpretation.

2. Presentation of the problem

The well-known reciprocity principle stands on the basis of many array configurations in electrical prospecting like pole - pole, dipole - dipole, Schlumberger, Wenner, etc. (Keller and Frischknecht 1966, Zabarovsky 1963, Frashëri et al. 1985). “According to the theorem of the reciprocity, no changes will be observed in the measured voltage if the placements of potential and current electrodes are interchanged. The reciprocity can readily be confirmed for an electrode array over a homogeneous earth” (Keller and Frischknecht 1966). Reciprocity principle has been discussed also by Parasnis D.S. (1988).

The heterogeneous medium presents a more complicated problem. Zabarovsky (1963) shows that if a body A has received an electrical charge Q_A, a body M will have a potential U_M related with the charge Q_A according to following the equation:

$$U_M = \alpha_{AM} \times Q_A$$

where α_{AM} is a coefficient dependant on the shape of bodies A and M, their reciprocal position and the boundaries of heterogeneity. If the reversed operation would take place, i.e. the body M to receive electrical charges of Q_M then the potential U_A of the body A would be:

$$U_A = \alpha_{MA} \times Q_M$$

In the electrostatic phenomena science it is proved that $\alpha_{AM} = \alpha_{MA}$. If this equality is true, then $Q_M=Q_A$ and as a consequence $U_M=U_A$. Translating this result into language of electrodynamics, one may say that the potential of electrode M created by the effect of electrode A would be equal to the potential of the electrode A, if the currents would be emitted in the ground by the electrode M, with the condition that the product $I * \rho$ remains the same. On this basis Zabarovsky (1963) concluded that the principle of reciprocity is valid for heterogeneous media as well. In homogeneous or horizontally stratified media the principle of reciprocity is true for any surveying array. In a heterogeneous environment this principle is absolutely true for four electrode Schlumberger, Wenner and pole-pole (half-Wenner) arrays. The dipole-dipole array presents a complex behaviour: for vertical targets of thickness $d > a$ (a stands for dipole spacing) the principle of reciprocity is met while for d comparable and thinner than a, the asymmetry is noticed in intensity and shape of the twin responses (Keller and Frischknecht 1966, Frasheri et al 1985). In IP method the principle of reciprocity is more complicated.

In several field surveys asymmetrical IP/Resistivity responses are observed with dipole – dipole array for opposite orientations of the potential and current electrodes in the survey line. To further investigate this phenomenon some mathematical models were carried out with a program of finite element method (Frasheri A. and Frasheri N. 2000).

In routine practice of electrical prospecting using dipole-dipole array little attention is paid to the evaluation of anomaly configuration regarding to position of target relative to current and receiving electrodes. In many publications with the results of forward modeling and inversion, the position of electrodes in the survey line is not shown (Dey, A., and Morrison, H. F., 1979,

Tsourlos, P.I., et al., 1998, Tsourlos, P. I. and Ogilvy, R. D. 1999). In certain conditions, this fact affects the results of target interpretation.

The mathematical computation of the IP effect is based on the Bleil 1953 and Seigel 1959 formulae:

$$U_{IP} = c \times \int_V \nabla U \times \left(\frac{1}{\vec{R}}\right) \times dv \qquad (1)$$

Where: U_{ip} is the IP potential;

$\vec{R}$ is the distance vector from the integration point to the receiving point;

∇U is the potential gradient of the primary electrical field, calculated by solving the finite element model.

To perform the mathematical modeling and the inversion of IP data, we have used the Komarov's (1972) approach:

$$C.(Uo+Uip) \approx C.Uo \qquad (2)$$

where: Uo is the potential of the primary electrical field,

Uip is the potential of the secondary electrical (IP) field,

C is the IP susceptibility.

Based on mathematical modeling of the IP anomalous field, there is a formal similarity of the polarizable medium and the increase of electrical specific resistivity of this medium as proposed by Komarov (1972) and used by many other authors (Avdeevic and Fokin 1992, Frasheri 1989, Frashëri et al 1994, Frashëri, and Frashëri 2000, Hmelevskoj and Shevshin 1994, Tsourlos , Szymanski and Tsokas, 1998, Tsourlos and Ogilvy, 1999):

$$\gamma^* = \gamma(1\text{-}m) \quad \text{or} \quad \rho^* = \frac{1}{\gamma(1-m)}; \qquad (3)$$

where: γ^*, ρ^* are fictive electrical conductivity and resistivity, considering the polarizability as well,

γ is electrical conductivity

m is IP chargeability

For 3D modeling of IP effect from targets with massive texture in homogeneous medium we have transformed the Bleil formulae, using Green's formulae (Frashëri N. 1983, Frashëri A., Frashëri N. 2000):

$$U_{IP} = c \times \int_S \left(\frac{1}{R}\right) \times \left(\frac{dU}{dn}\right) \times ds \qquad (4)$$

Where: R is the distance vector from the integration point to the measurement point

dU/dn is the gradient of the primary electrical potential on the boundary S of the target.

Fig.1 indicates the results of a mathematical IP model through finite element method, compared to a similar field situation. With the same method of finite elements, simultaneously with the IP effect, the apparent resistivity is calculated as well.

In Fig.2 are given the IP profiles obtained theoretically, calculated with our program and observed in scale model. In both figures it is noticed that the accuracy of mathematical model is good.

2. Numerical results for different models

Figs. 3 and 4 present the mathematical model results of IP and resistivity responses with dipole–dipole profiling. Two anomalies are observed on both parameters. Considering the reference plotting point in between the potential electrodes P_1 and P_2, one of the anomalies is obtained over the prism while the second one at a distance O_1O_2 , between the centers of the current and potential dipoles. This presentation is conditioned on the distribution of electrical field of the dipole - dipole array. Because a mirror image is missing in the center of the profiles, especially for IP, it means that $C_1C_2P_1P_2$ array responses are not equivalent with $P_1P_2C_1C_2$, or in mathematical terms, the principle of reciprocity is not strictly met. Keller (1966) presents the same phenomenon for the apparent resistivity.

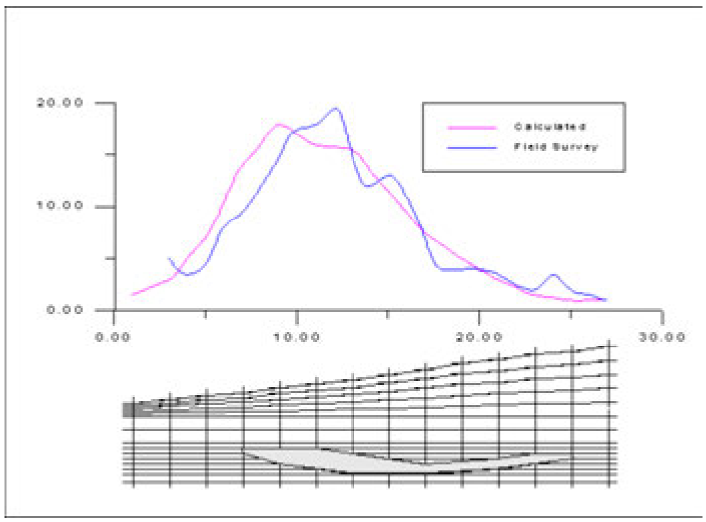


Fig. 1. A finite element section of an IP irregular body over a relief.

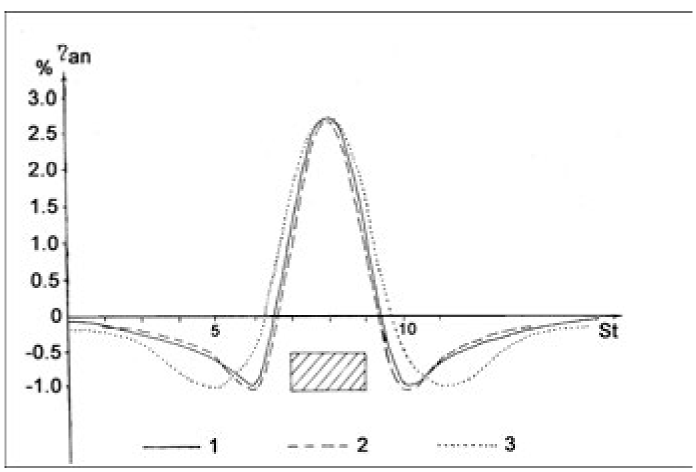


Fig. 2. IP profiling over a prism: Theoretical, calculated and physical modeling.

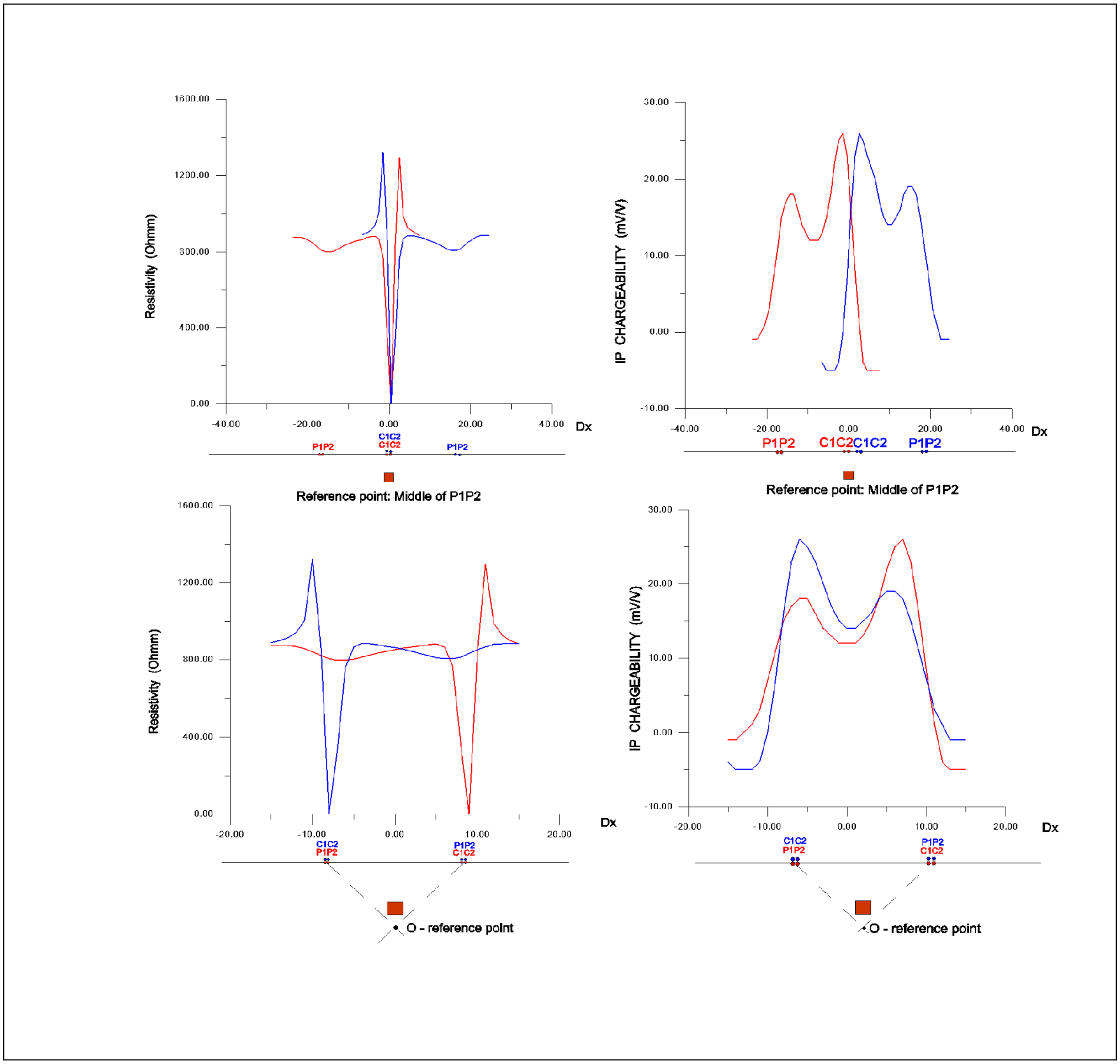


Fig. 3. IP and Resistivity mathematical modeling. Dipole-dipole profiling, C_1C_2-P_1P_2=1 Dx, n=16 Dx.

Model: 2D horizontal prism at depth 5 Dx, dimensions of the prism section 2 x 2 Dx.

Resistivity of the prism 1 Ohmm, IP Chargeability 500 mV/V, Resistivity of the environment 1,000 Ohmm, IP Chargeability of the environment 0.01 mV/V.

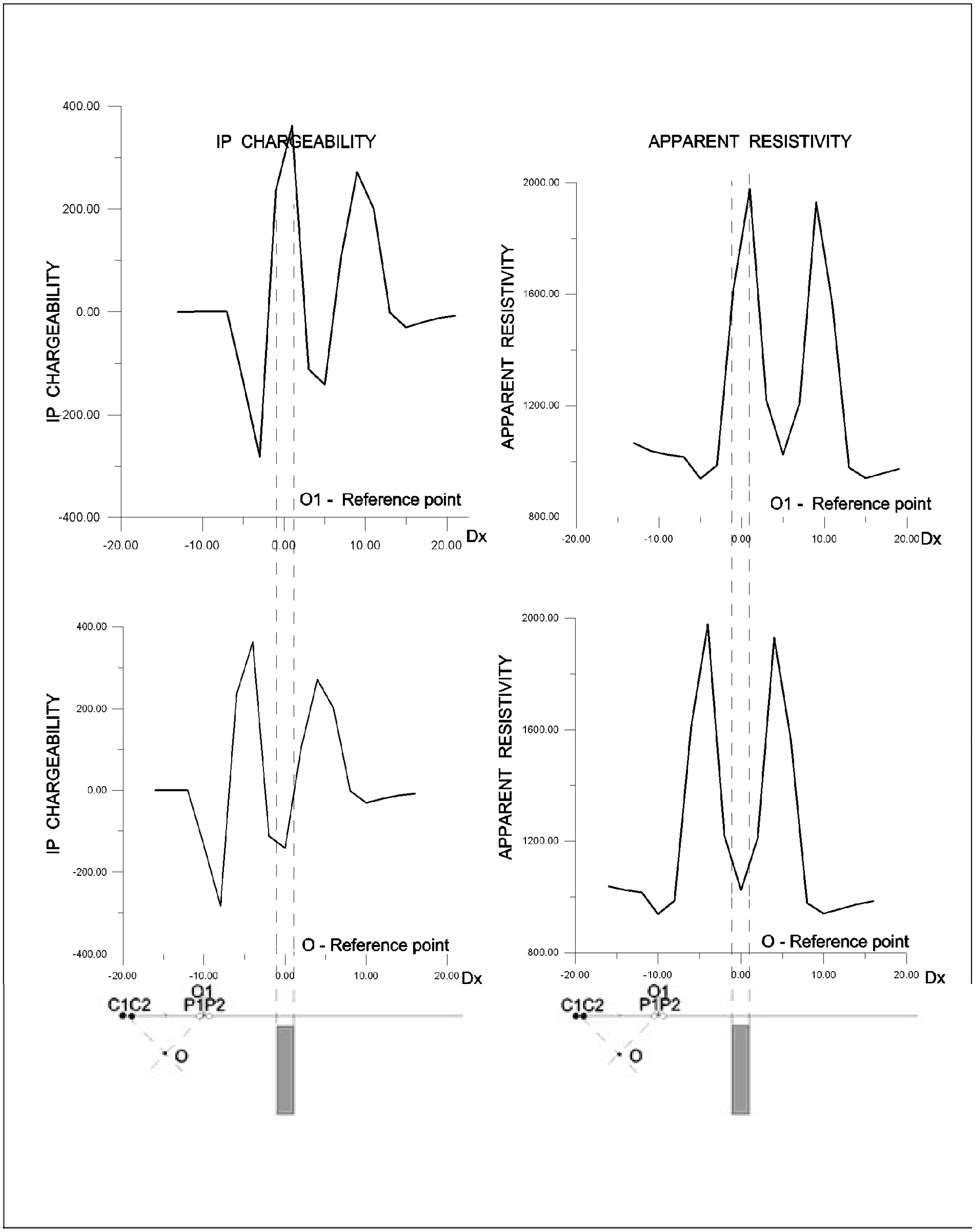


Fig. 4. IP and Resistivity mathematical modeling. Dipole-dipole profiling. C_1C_2-P1P2=2 Dx, n=1-10 Dx.

Model: 2D vertical prism at depth 1 Dx, dimensions of the prism section 2 x 9 Dx. Resistivity of the prism 20,000 Ohmm, IP Chargeability 500 mV/V, Resistivity of the environment 1,000 Ohmm, IP Chargeability of the environment 0.01 mV/V.

In pseudosection presentation, where the plotting point is located at the intersection of lines coming at 45° from midpoints between C_1C_2 and P_1P_2, these anomalies are located in both sides of the prism (Figs. 5, 6, 7, 8). For the resistivity parameter this location is almost symmetrical in shape and amplitude, for the vertical target (Fig. 5). The symmetry is perfect in cases when the thickness of the prism is equal or greater than the dipole spacing "a", and becomes poor for thinner prisms (Fig. 8).

Alternatively, the IP anomalies are asymmetrical even in cases of vertical prisms (Fig. 3, 5 and 8). In such cases, the epicentre of the most intensive anomaly is displaced on the side of current dipole C_1C_2. For shallow inclined prisms, the epicentres of both IP and resistivity anomalies are displaced on the opposite side of the dip.

The configuration of the IP/Resistivity anomaly is also dependent on the dip angle amplitude, relative to the current electrodes location.

The substantial difference between the electric field distributions in both cases clearly expresses the changes in IP anomaly configurations for gradient and dipole-dipole arrays. Fig. 9 depicts such variations. The amplitude and the asymmetry of IP anomaly depend on the orientation of the polarizing vector of the primary electric field in connection to the prism location. In fig. 10 is presented the electric polarizing field distribution for the gradient array and dipole-dipole array.

The response becomes more complicated when several targets are located under the surveying line. For a situation with two parallel polarisable inclined prisms like that in fig. 11, both C_1C_2-P_1P_2 and P_2P_1-C_2C_1 dipole-dipole arrays obtain a single IP anomaly in the centre and present some differences in contours shape. A formal interpretation or even an inversion on these results cannot outline the presence of two distinct targets. Our mathematical model with IP "Real Section" array (Alikaj 1981, Langore Alikaj and Gjovreku 1989, Lubonja, Frashëri and Alikaj 1994) over the same targets, however, provides a different picture with two distinct anomalies (Fig. 12).

In parallel with mathematical modelling, the asymmetrical configuration of the IP and resistivity anomalies depending on location of current and potential dipoles in relation to polarisable target is also supported by the scale modeling (Fig. 13).

Asymmetrical IP and resistivity anomalies, depending on the location of current and potential dipoles in relation to target is not always without problems in manual or inversion interpretations of the IP/Resistivity data surveyed with a dipole–dipole array.

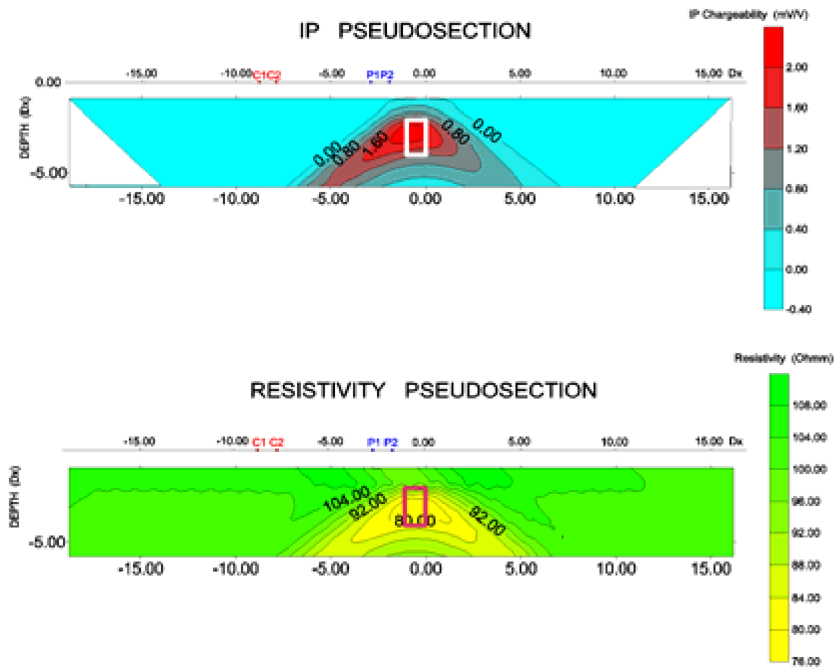


Fig. 5. IP and Resistivity Pseudosection with dipole-dipole array. C_1C_2-P_1P_2=1 Dx, n=1-11 Dx. Mathematical model: 2D vertical prism at depth 2 Dx, dimensions of the prism section 1 x 2 Dx. Resistivity of the prism 1 Ohmm, IP Chargeability 300 mV/V, Resistivity of the environment 100 Ohmm, IP Chargeability of the environment 0.01 mV/V.

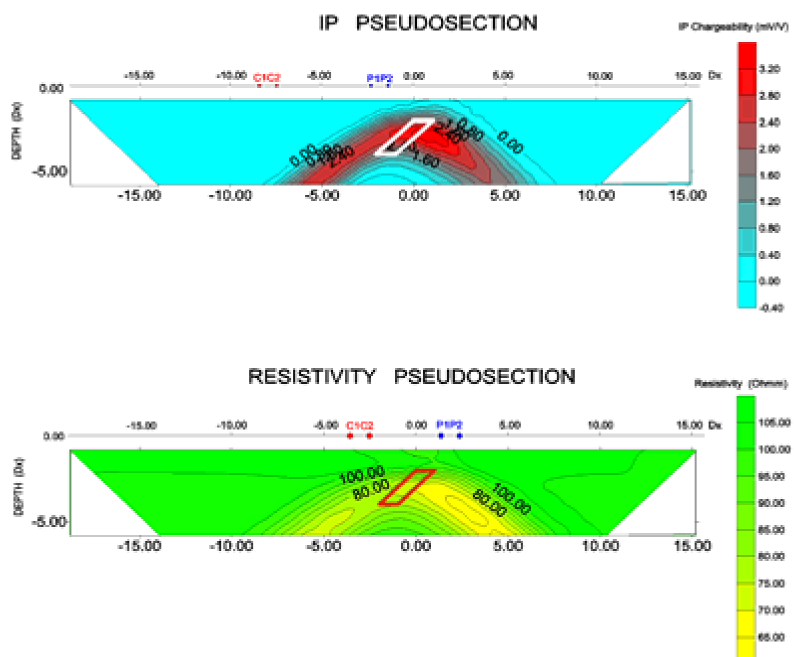


Fig. 6. IP and Resistivity Pseudosection with dipole-dipole array, C_1C_2-P_1P_2=1 Dx, n=1-11 Dx. Mathematical model: 2D inclined prism at depth 2 Dx, dimensions of the prism section 1 x 2 Dx. Resistivity of the prism 1 Ohmm, IP Chargeability 300 mV/V, Resistivity of the environment 100 Ohmm, IP Chargeability of the environment 0.01 mV/V.

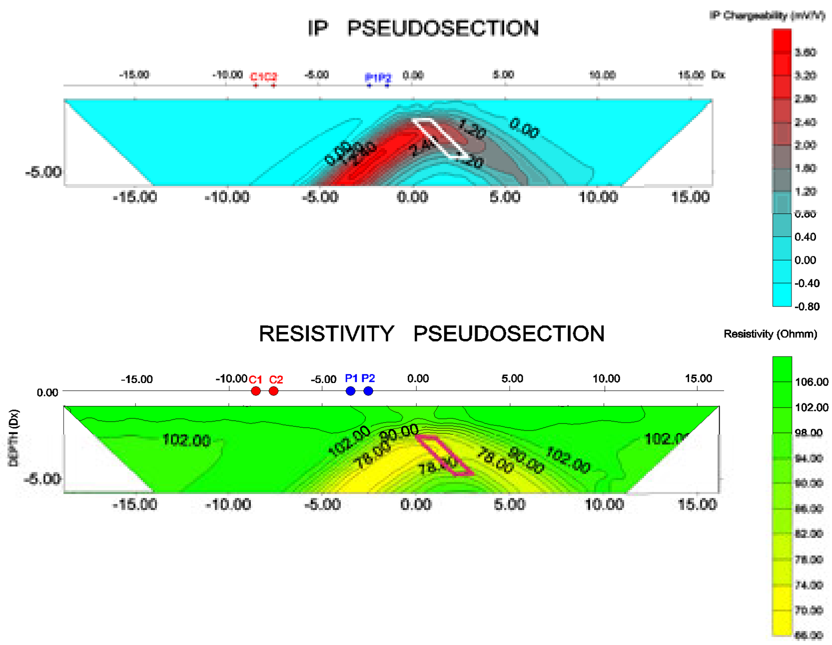


Fig. 7. IP and Resistivity Pseudosection with dipole-dipole array, P_1P_2-C_1C_2=1 Dx, n=1-11 Dx. Mathematical model: 2D inclined prism at depth 2 Dx, dimensions of the prism section 1 x 2 Dx. Resistivity of the prism 1 Ohmm, IP Chargeability 300 mV/V, Resistivity of the environment 100 Ohmm, IP Chargeability of the environment 0.01 mV/V.

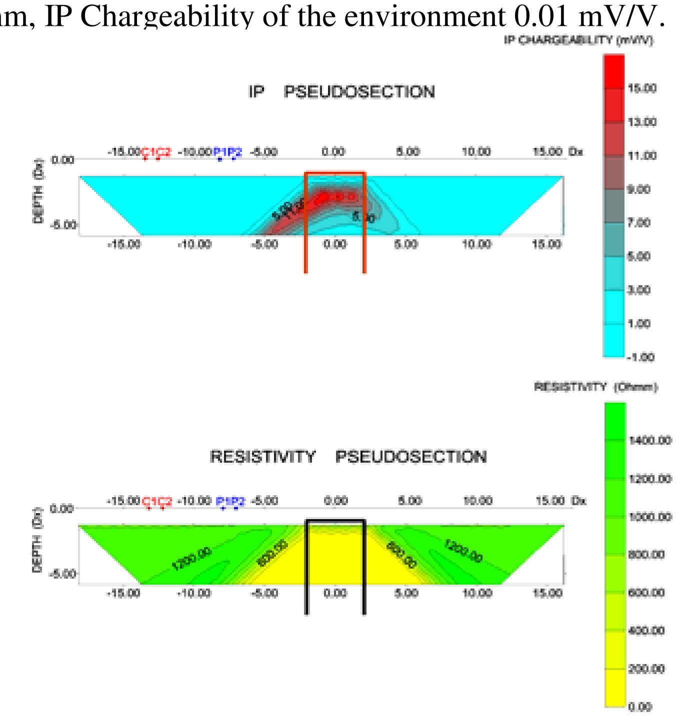


Fig. 8. IP and Resistivity Pseudosection with dipole-dipole array, C_1C_2-P_1P_2=1 Dx, n=1-11 Dx. Mathematical model: 2D vertical prism at depth 1 Dx, dimensions of the prism section 4 x 50 Dx. Resistivity of the prism 3 Ohmm, IP Chargeability 50 mV/V, Resistivity of the environment 1,000 Ohmm, IP Chargeability of the environment 0.01 mV/V.

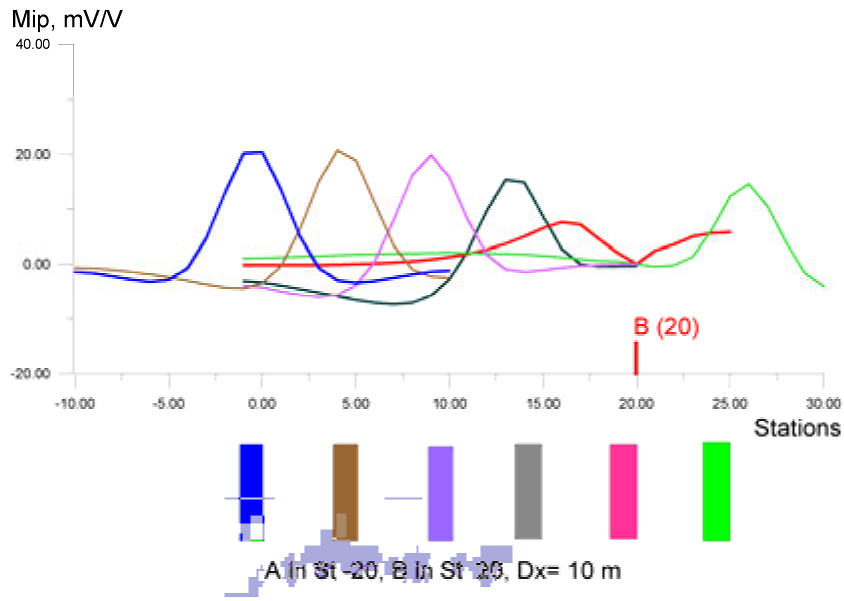


Fig. 9. IP anomaly configuration dependence on location of the target.

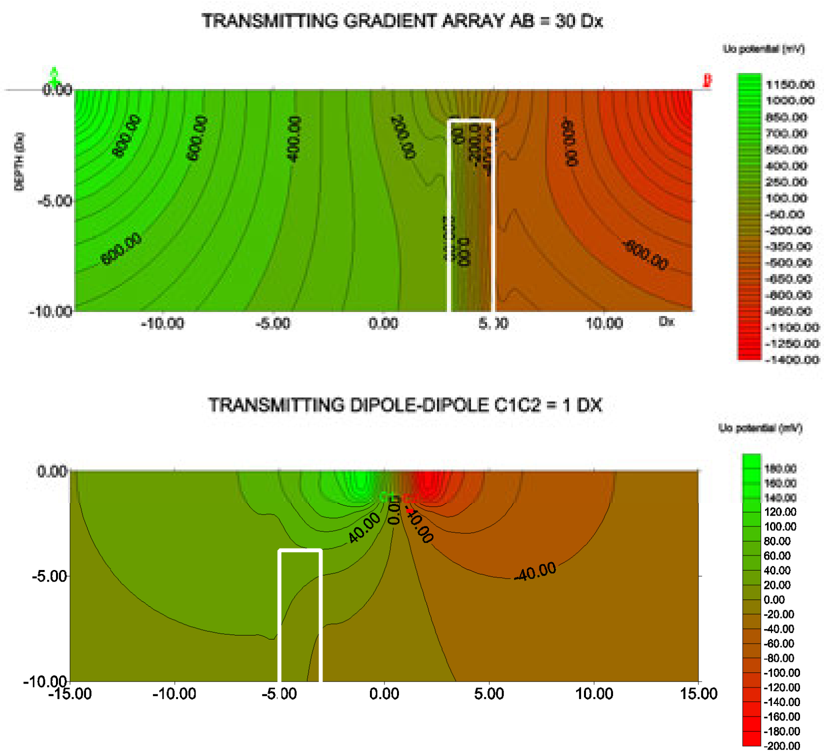
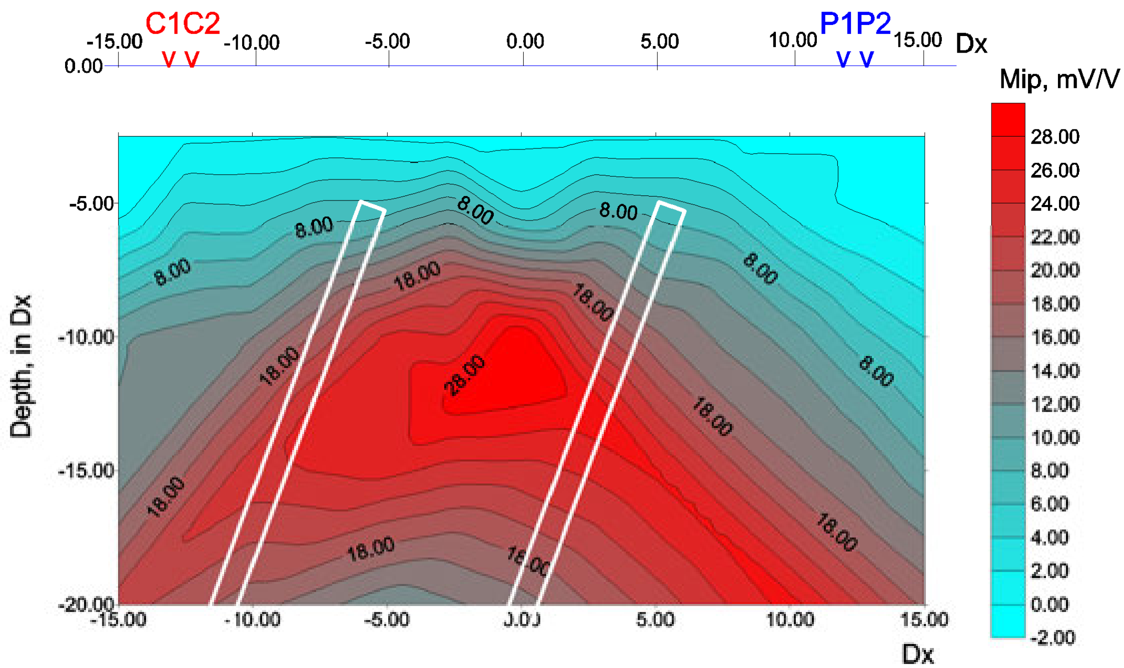


Fig. 10. Distribution of the primary electric field potential (Uo) of a transmitting dipole:

(a) Gradient array $AB_{max} = 30$ Dx

(b) Dipole-dipole array $C_1C_2 = 1$ Dx.

Mathematical model: Vertical prism. Dimensions of the prism 2 x 30 x 20 Dx, Resistivity of the prism 20,000 Ohmm, Resistivity of the environment 1,000 Ohmm.



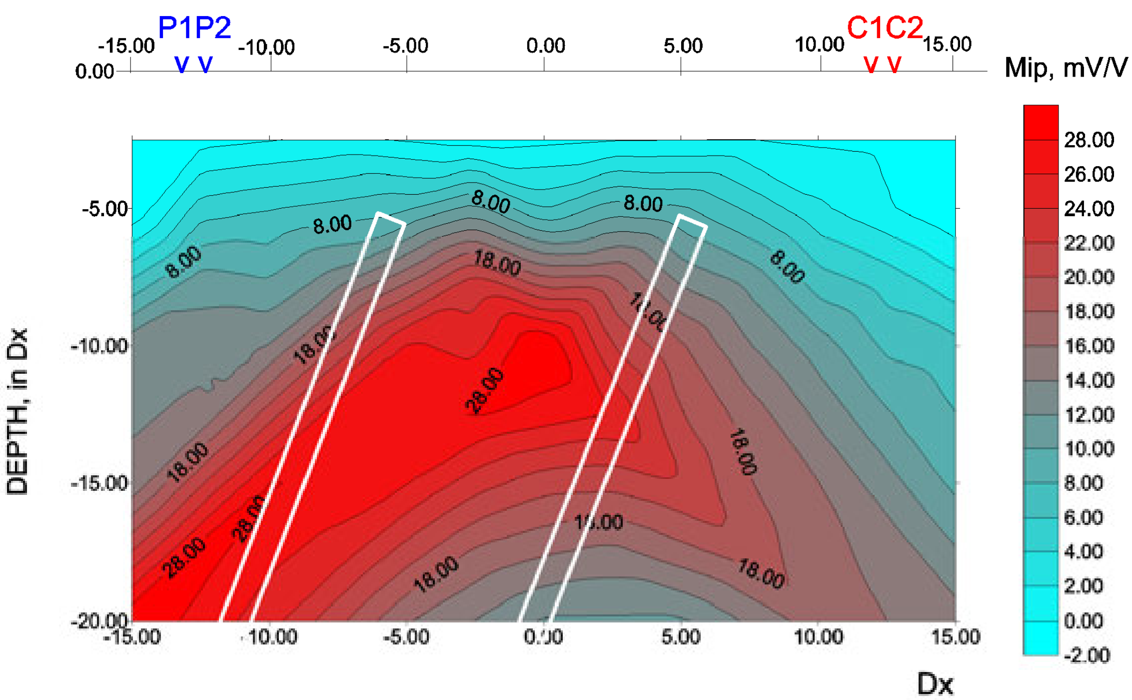


Fig. 11. IP Pseudosection with dipole-dipole array, $C_1C_2=P_1P_2=1$ Dx, n=1-39.
Mathematical Model: Two parallel inclined prisms (dip=70^o) at depth 5 Dx, dimensions of the prisms 1 x 20 x 20 Dx. Distance between the prisms 10 Dx, Resistivity of prisms 2000 Ohmm, IP Chargeability 500 mV/V, Environment Resistivity 500 Ohmm , IP Chargeability 0.01 mV/V.

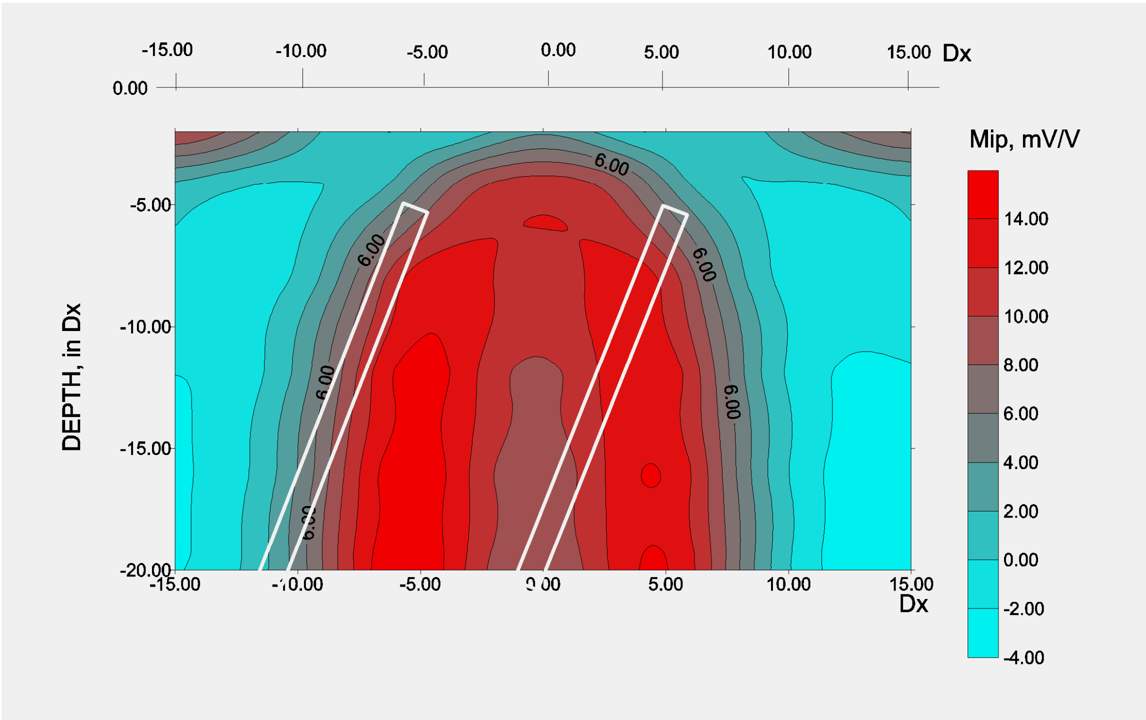


Fig. 12. IP "Real Section" with multiple gradient arrays. IP contour interval 2 mV/V.
Mathematical Model: Two parallel inclined prisms (dip=70^o) at depth 5 Dx, dimensions of the prisms 1 x 20 x 20 Dx. Distance between the prisms 10 Dx, Resistivity of prisms 2,000 Ohmm, IP Chargeability 500 mV/V, Environment Resistivity 500 Ohmm, IP Chargeability 1 mV/V.

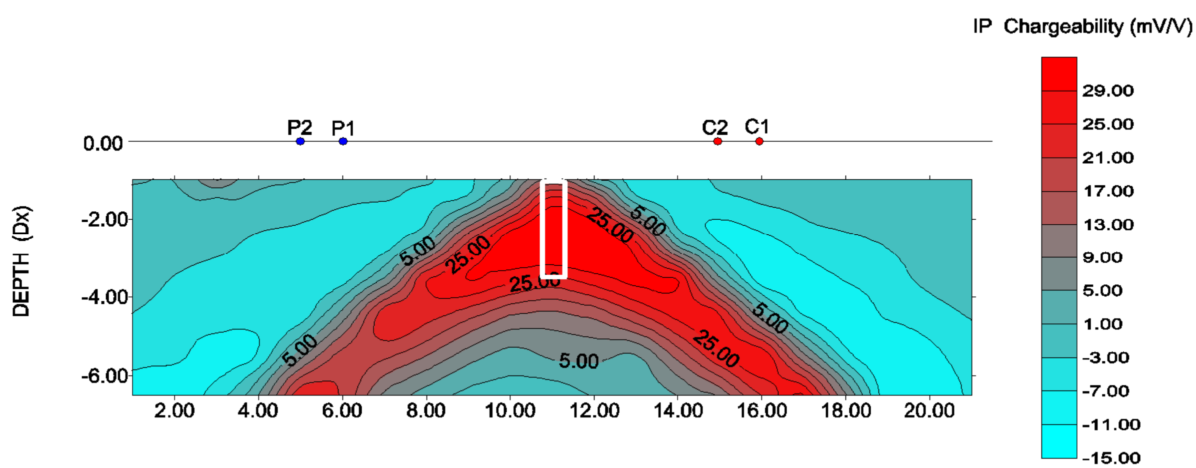


Fig. 13. IP Pseudosection with dipole-dipole array, P_1P_2=C_1C_2=1 Dx, n=1-24.
2D Scale Model: Target: Copper vertical prism at depth 1 Dx,
Section of the prism 0.5 x 2.5 Dx

3. Some considerations on IP data inversion

The inversion of IP data became a necessity to better define the attitude of a target in complex configuration of IP anomaly in section due to migration and array geometry.

In this part of the paper aspects of IP data inversion theory are considered, as well as resolution capability and stability of inversion solutions. This analysis is based also on new data from mathematical and physical modeling of abnormal IP effect, taking into account aspects of non-linear IP phenomenon.

The calculation of IP effect is based on the formula of Bleil. The evaluation of Komarov is used for both modeling and inversion of IP data, supposing a formal similarity of environment polarization with the increasing of its specific electrical resistivity. In all calculations, the effect of IP is supposed to be a linear phenomenon. Such modelling and inversions of IP pseudosections, carried out by many authors, have been steps forward for the interpretation of IP survey data and for the evaluation of IP method. But new facts on the non-linear nature of IP phenomenon, together with results of mathematical and physical modeling of last ten years rise new problems in IP modeling and inversion. If these problems will remain unsolved, the effectiveness of IP method will make no progress.

It is known that IP is considered as a linear phenomenon in all mathematical calculations, including inversion which creates several characteristics in the configuration of the mathematically calculated IP anomalies (Fig.5, 6, 7):

1. The upper part of anomaly corresponds with the upper edge of the polarized target.
2. Anomalies remain open towards the depth, even below the bottom edge of the targets.

Continuation of IP anomalies below bottom edge of targets makes the interpretation difficult and target extension determination at depth as unsure. The presentation of anomalies is more complex in pseudosections, for dipole-dipole survey configuration (Fig.5, 6, 7, 8, 10, 11). Migration of anomalies in pseudosections depends on dip angle of the targets and on position of transmitting and receiving dipoles relative to target (there are left-arrays C_1C_2-P_1P_2 and right-arrays P_1P_2-C_1C_2). The reason of such configuration of IP anomalies is due to assumption on linear behaviour of IP phenomenon in mathematical calculations, namely the primary and secondary voltages are linear in a broad band.

Due to the different polarizing situations, IP phenomenon is characterized by:

1. Near surface targets, due to surface polarization (massive sulphide) reach the nonlinearity regime of the secondary (IP) voltage very easily, because a major part of current density is attracted by them. As a result, the secondary voltage is grown faster than the primary voltage and consequently, their ratio (chargeability) reflects higher values.
2. Increasing the current dipole spacing in order to increase the depth of investigation, significant decrease of the primary (polarizing) voltage will take place at depth (Fig.10). Due to decreased current density, the secondary (IP) voltage will bear at its linear behaviour (proportional to primary voltage) and as a result a smaller chargeability anomaly will be obtained at depth. In Fig. 14 is presented an IP “Real Section” obtained in 2D scale model for a limited copper model at depth. As can be noticed, the IP contours outline a stronger

anomaly near the surface and they pinch out below the model bottom part. This is a clear non-linear effect of the IP phenomenon obtained in physical models that cannot be replicated in mathematical ones.

Voltage of the polarizing electric field at the depth 50 meters,
in the environment with resistivity 1,000 Ohmm.

Tab.1

Current Electrodes C1C2 spacing, [in meters]	Voltage of the polarizing electric field, [in mV/m]
100	33.960
500	53
1000	13
2000	3
3000	1,4

3. The distributed IP effect is defined by survey arrays. This distribution is symmetric for gradient array, but asymmetric for dipole-dipole and pole-d ipole arrays (Fig. 10), making a necessity the inversion of IP data.

In contrast, the resistivity anomalies indicate closed contours below the target.

The stability and uniqueness of IP inversion solutions depend also on application of a linear model for the IP phenomenon, but that is not quite true for the whole variation of applied polarizing voltage. As a result, the lower part of polarized targets is instable in IP inversions. It becomes more instable when several targets are situated close to each other or in cases of targets near contacts between environments of different chargeability and resistivity. The increase of depth of targets causes the increase in inversion solution instability and resolution capability.

4. IP/Resistivity" Real Section" - a solution

Due to different polarizing situations, IP phenomenon is markedly conditioned by the significant decrease of the polarizing voltage at depth. Increasing the investigation depth, different parts of the same target, as well as targets located at different depths, are found in different polarizing conditions. This fact is clearly expressed in a contradiction between observed geoelectrical sections and numerical linear IP models for mathematical inversions at any polarizing voltages. As a result, the lower part of polarized target is instable in IP inversions. It becomes more instable when several targets are situated near to each other or in cases of targets near contacts between environments of different polarization and resistivity (Fig. 11). The increase of target's depth is accompanied by increasing of the inversion stability and decreasing of its solution's capability. At present level of the inversion, only the top of target is relatively well - determined in inverted section. The bottom edge of model remains uncertain as a-priory. A little can be determined as regard to deep angle in a qualitative way. In inversion section can be obtained some qualitative information on shape of the polarisable body as well.

IP "Real Section" performed with multiple gradient arrays or Vertical Electrical Soundings is actually the most appropriate scientific technique in presentation of anomalous chargeability distribution at section (Figs.14-20) (Alikaj 1981, Alikaj and Gordon 1999, Langore, Alikaj and Gjovreku 1989, Lubonja, Frasheri and Alikaj 1994). In difference to pseudo-section there is no lateral migration on top of target IP anomaly. Here are excluded the cases of lateral influence of other polarisable objects (Fig. 12). The "Real Section" presentation being very close to reality provides also very accurate results in "Real Section" inversion which leads to accurate verifications in mining works or drillings over IP anomalies Fig. 15, 16a, 16b, 17, 18, 19). The IP "Real Section" technique (Langore, Alikaj & Gjovreku, 1989) in field

surveys as well as physical models (Alikaj 1981) indicate a discrepancy in some cases with mathematical models (Frashëri A. and Frashëri N 2000). These cases include shallow locations of massive sulphide ore bodies or models (Fig. 18) and as explained above, it is connected to non-linear behaviour of IP phenomenon.

To achieve the level of today's requirements in certainty of surveys with IP method it is an imperative duty to be well studied the nonlinear nature of IP phenomenon. This will allow to be built an appropriate mathematical apparatus with real situation on this natural phenomenon. Only in that case, the inversion can be more accurate, in levels that allow its instability and non-uniqueness in its solution.

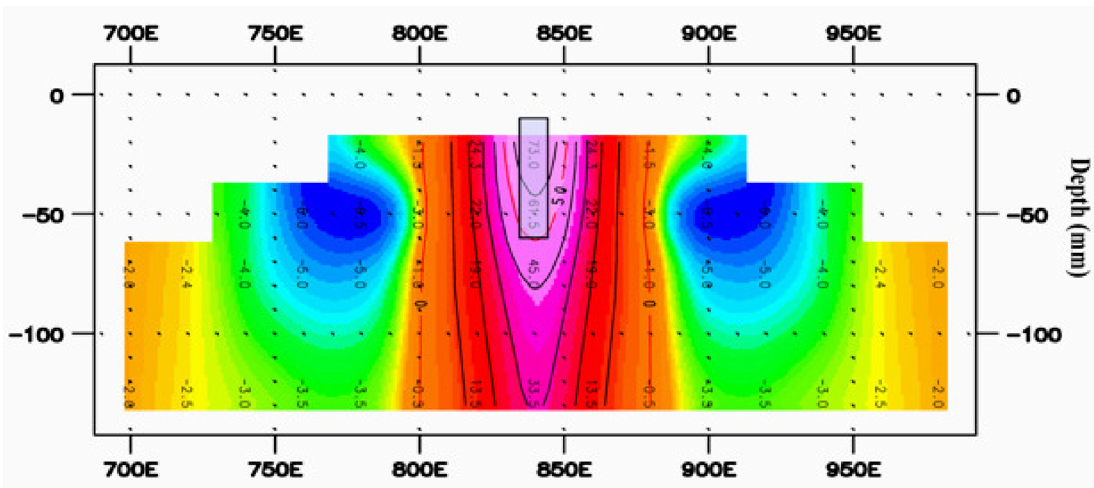


Fig. 14. Gradient "Real Section", 2D IP scale model. Array (MN=20 mm)

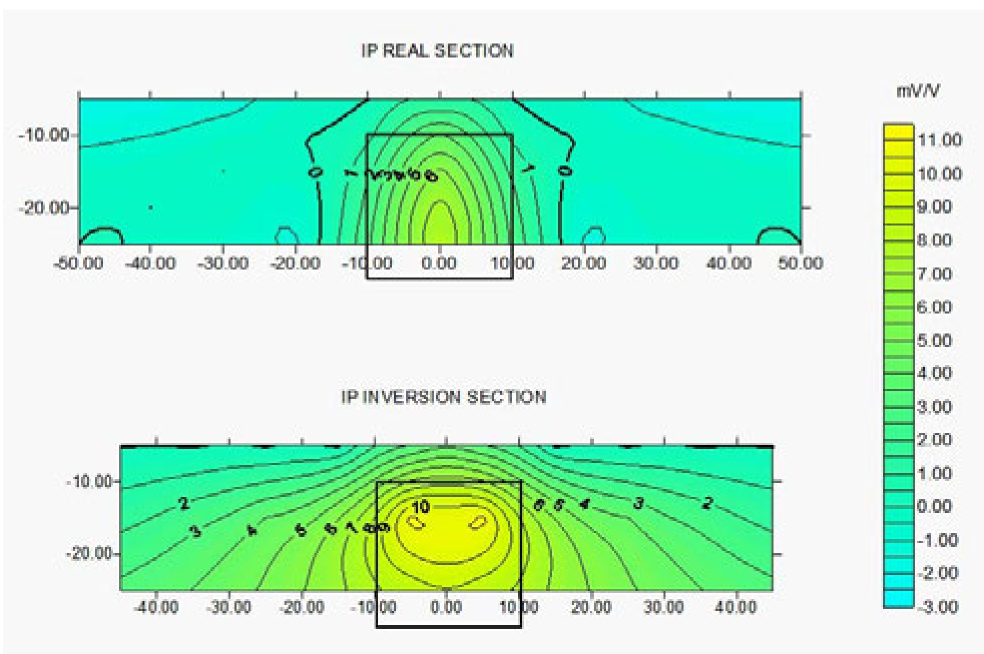


Fig. 15. IP "Real Section" and its Inversion Section.
2D Mathematical Model: Target: Prismatic Body, depth 10 m, height 20 m, width 20m, chargeability 200 mV/V.

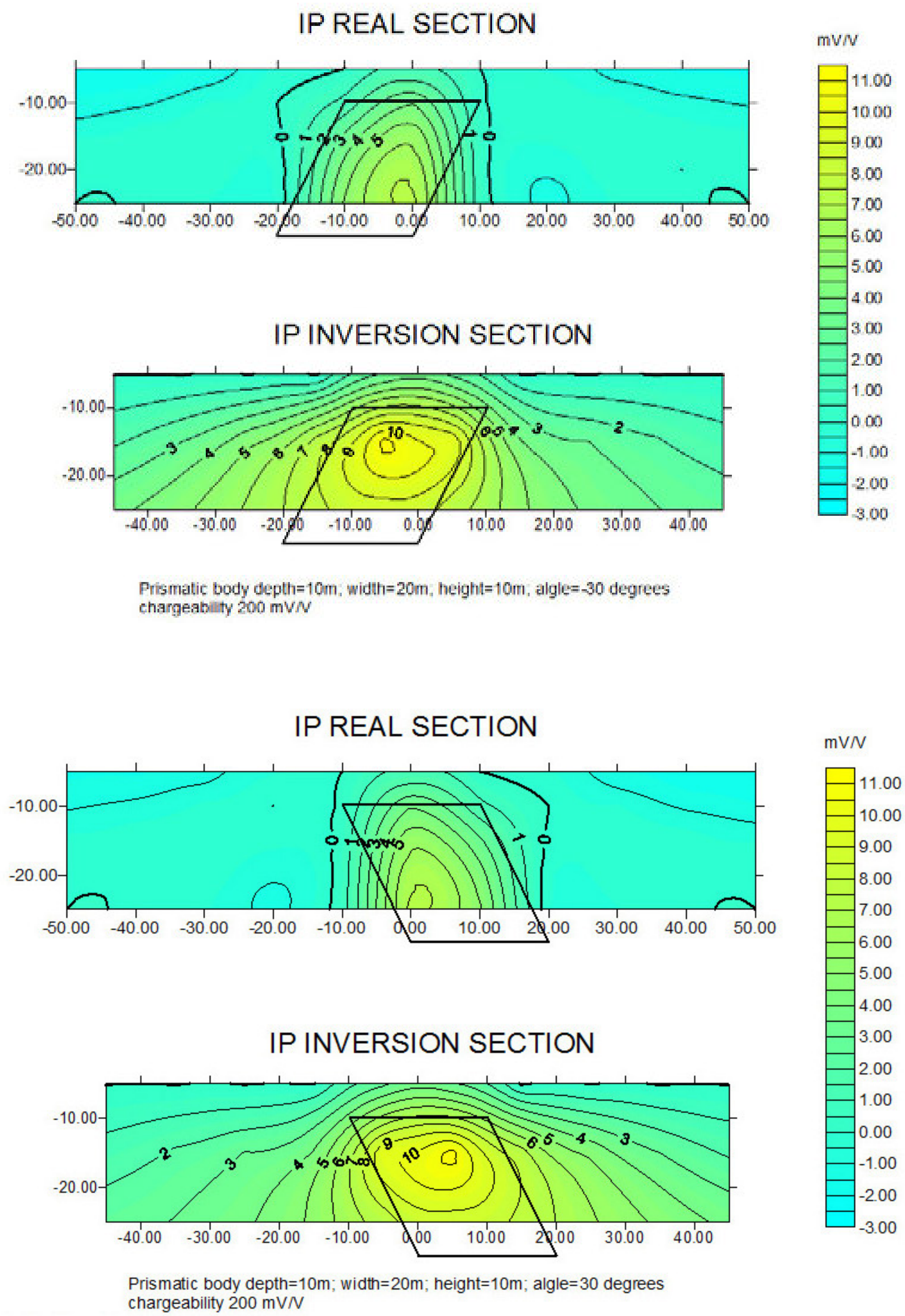


Fig. 16. IP "Real Section" and its Inverted Section.
2D Mathematical Model: Target: Prismatic Body, depth 10 m, height 20 m, width 20m, dip angle 60^o, dip azimuth 90^o, chargeability 200 mV/V.

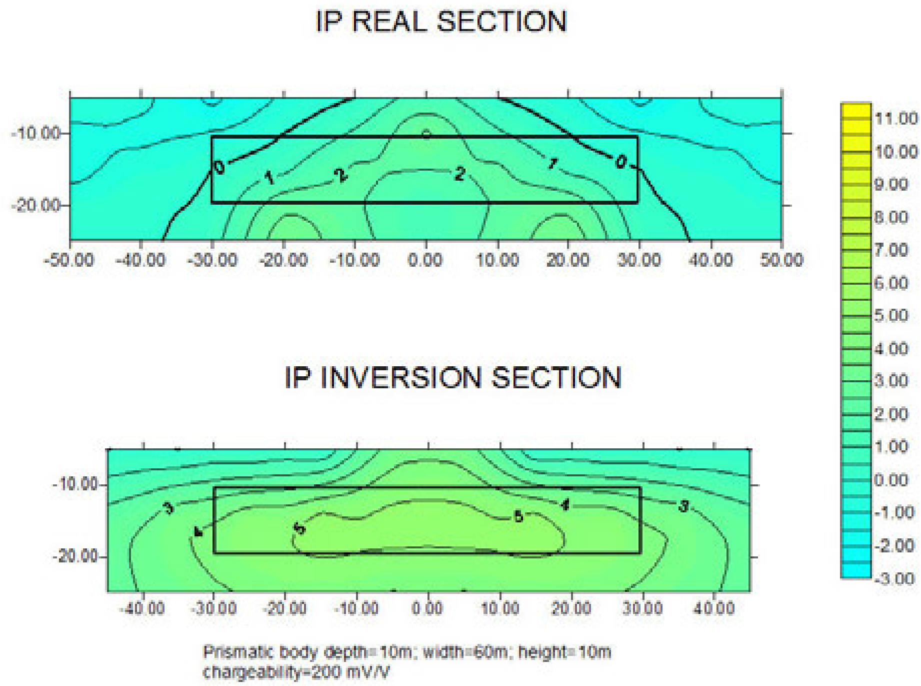


Fig. 17. IP "Real Section" and its Inverted Section.
2D Mathematical Model: Target: Horizontal Prismatic Body, depth 10 m, height 10 m, width 60m, chargeability 200 mV/V.

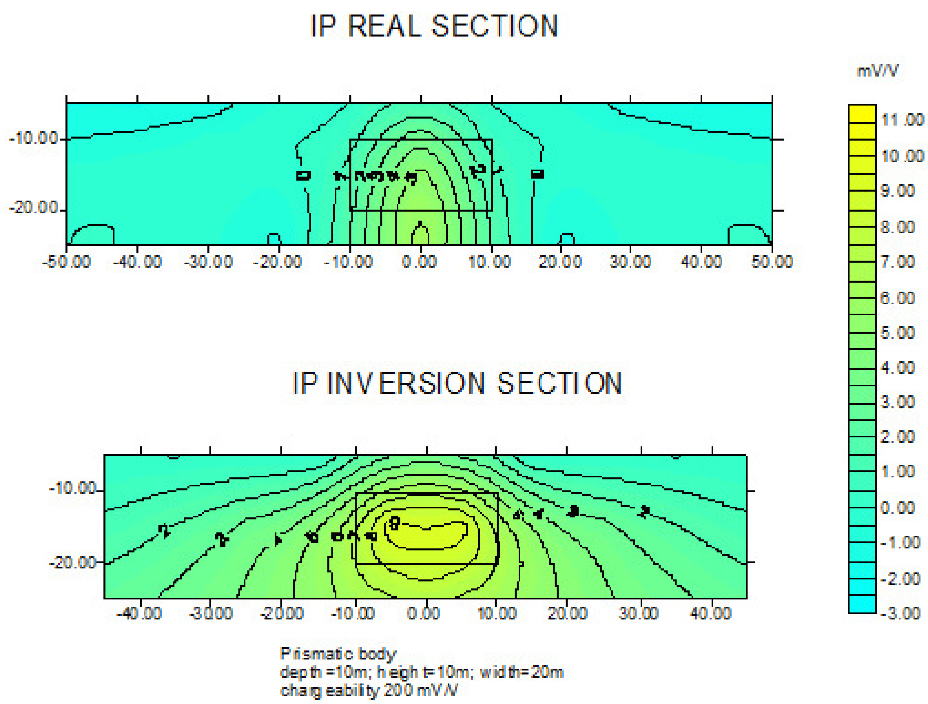


Fig. 18. IP "Real Section" and its Inverted Section. 2D Mathematical Model: Target: Horizontal Prismatic Body, depth 10 m, height 10 m, width 20m, chargeability 200 mV/V.

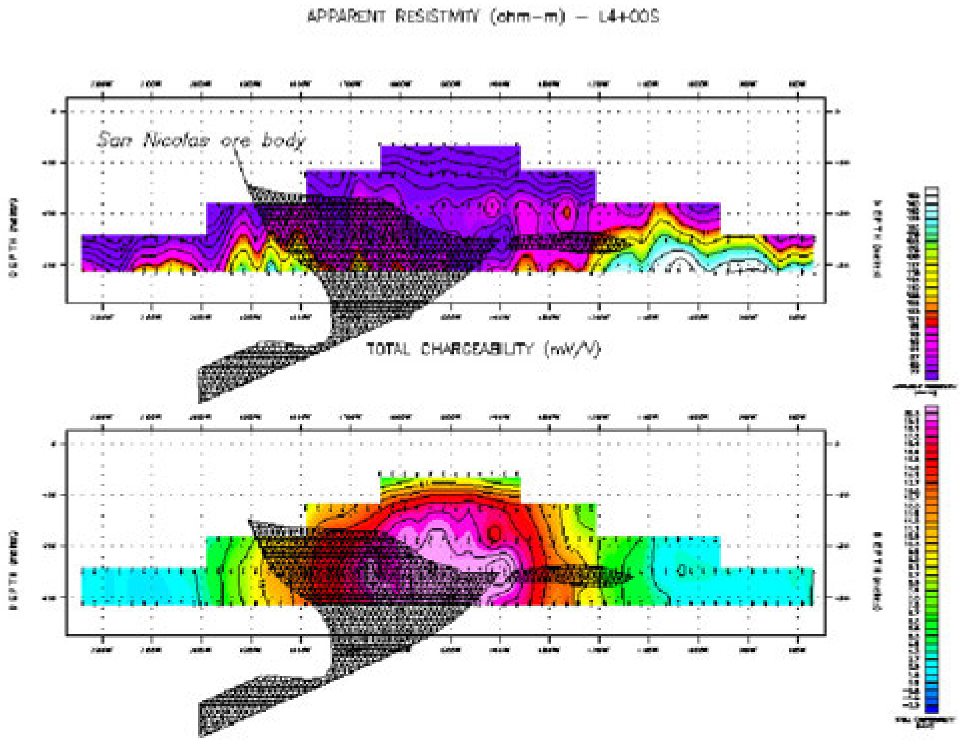


Fig. 19. Resistivity and IP "Real Sections" over San Nicolas polymetallic ore deposit, Mexico

Conclusions

1. The anomaly configuration in an IP/Resistivity survey with a dipole–dipole array is dependent on the location of the current and potential electrodes in connection to target. In this regard, logistical information about the survey should include the array orientation (left-array or right-array). The position of the array must be shown in plots and pseudo-sections. During the survey, it is necessary to keep the same orientation of current and receiving dipoles.

2. Physical modeling of IP shows the proof that there are differences between field survey cases and mathematical models. In sections compiled with data from physical models the anomalies are closed under the lower edge of the near surface target. In sections of mathematical linear models, the IP anomalies remain open at depth, contrary to those of apparent resistivity. This is due to the fact that in mathematical formulas the IP chargeability is considered as a linear phenomenon in the whole range of variation of polarizing voltage.

3. The use of mathematical formulas for inversion based on the linear IP phenomenon implies errors in compilation of sections based on approximation of inverted data. These errors may be comparable to instability of the inversion itself.

4. To achieve the levels of actual requirements for the quality of IP surveys, it is necessary to well evaluate the non-linear character of IP phenomenon. It would permit a better conception of mathematical basis of IP, as well as a better match with the real situation of the phenomenon in nature. Used with the IP inversion, these new mathematical non-linear equations would permit more exact results as compared to the instability and non-uniqueness of inversion solutions.

5. An accurate interpretation of IP/Resistivity data with dipole-dipole array should consider the information on electrode orientation on the survey line. The same recommendation is valid for the process of inversion interpretation.

6. The IP/Resistivity "Real Section" survey with multiple gradient arrays or series of Vertical Electrical Soundings provides a good corroboration between these electrical parameters and geological environment in section. The inversion of IP/Resistivity "Real Section" survey provides accurate results because the initial model provided by "Real Section" presentation is very close to reality.

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LIST OF CAPTIONS

Fig. 1. A finite element section of an IP irregular body over a relief.

Fig. 2. IP profiling over a prism: Theoretical, calculated and physical modeling.

Fig. 3. IP and Resistivity mathematical modeling. Dipole-dipole profiling, C_1C_2-P_1P_2=1 Dx, n=16 Dx.
Model: 2D horizontal prism at depth 5 Dx, dimensions of the prism section 2 x 2 Dx. Resistivity of the prism 1 Ohmm, IP Chargeability 500 mV/V, Resistivity of the environment 1,000 Ohmm, IP Chargeability of the environment 0.01 mV/V.

Fig. 4. IP and Resistivity mathematical modeling. Dipole-dipole profiling. C_1C_2-P1P2=2 Dx, n=1-10 Dx.
Model: 2D vertical prism at depth 1 Dx, dimensions of the prism section 2 x 9 Dx. Resistivity of the prism 20,000 Ohmm, IP Chargeability 500 mV/V, Resistivity of the environment 1,000 Ohmm, IP Chargeability of the environment 0.01 mV/V.

Fig. 5. IP and Resistivity Pseudosection with dipole-dipole array. C_1C_2-P_1P_2=1 Dx, n=1-11 Dx.
Mathematical model: 2D vertical prism at depth 2 Dx, dimensions of the prism section

1 x 2 Dx. Resistivity of the prism 1 Ohmm, IP Chargeability 300 mV/V, Resistivity of the environment 100 Ohmm, IP Chargeability of the environment 0.01 mV/V.

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Fig. 7. IP and Resistivity Pseudosection with dipole-dipole array, P_1P_2-C_1C_2=1 Dx, n=1-11 Dx. Mathematical model: 2D inclined prism at depth 2 Dx, dimensions of the prism section 1 x 2 Dx. Resistivity of the prism 1 Ohmm, IP Chargeability 300 mV/V, Resistivity of the environment 100 Ohmm, IP Chargeability of the environment 0.01 mV/V.

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Fig. 13. IP Pseudosection with dipole-dipole array, P_1P_2=C_1C_2=1 Dx, n=1-24.

2D Scale Model: Target: Copper vertical prism at depth 1 Dx,

Section of the prism 0.5 x 2.5 Dx

Surrounding medium: fresh water

Fig. 14. 2D IP Chargeability scale model. Gradient "Real Section" Array (MN=20 mm)

Fig. 15. IP Real Section and its Inverted Section. 2D Mathematical Model: Target: Prismatic Body, depth 10 m, height 20 m, width 20m, chargeability 200 mV/V.

Fig. 16. IP "Real Section" and its Inverted Section. 2D Mathematical Model: Target: Prismatic Body, depth 10 m, height 20 m, width 20m, dip angle 60^o, chargeability 200 mV/V.

Fig. 17. IP "Real Section" and its Inverted Section. 2D Mathematical Model: Target: Prismatic Body, depth 10 m, height 10 m, width 60m, chargeability 200 mV/V.

Fig. 18. IP "Real Section" and its Inverted Section.

2D Scale Model: Target: Prismatic Body, depth 10 m, height 10 m, width 20m, chargeability 200 mV/V.

Fig. 19. IP/Resistivity "Real Section" over San Nicolas polymetallic ore deposit, Mexico.

3rd International Conference - Geosciences and Environment (3ICGE) 27-29 May 2012 Belgrade, Serbia
Lecture

PROBLEMS DURING GEOPHYSICAL EXPLORATION OF CHROMITE DEPOSITS

Many geophysical studies carried out in the ultrabasic massifs of Albania (as in Bulqiza, Tropoja, Kukesi, Shebeniku, Pogradeci etc) for the search for chrome deposits, which have been successful in many cases. They demonstrated that the geophysical methods are a part of the integrated methods for the search for this mineral ore. A long list of many scientific publications, on this item, is presented in the references.

4.1. Exploration for chrome ore bodies

The main principle for the application of the geophysical methods for the search for chrome ores, has been to start with the mapping in well known zones of the mineralization and to extend this mapping further to unknown zones, on surface and in the depth.

The works carried out only in Bulqiza ultrabasic massif can illustrate the effectiveness of the geophysical search for chrome ores. Geological and geophysical mappings, at scale 1:2000 have been conducted in total over 65 km^2 or in 15% of surface of the Bulqiza massif (Ll. Langore tec. 1989). There are observed 215 geophysical anomalies have been fixed. Among them, 191 anomalies have been observed by only of one geophysical method, and 24 ones present complex anomalies: gravity, magnetic or IP. From 64 anomalies, 51 anomalies were fixed over the known chromite bodies/occurrences and have contributed for their development in the strike direction. Thirteen anomalies have been discovered buried chromite bodies without surface outcrops, which have been explored by trenches, galleries and drill holes. Thirty-five anomalies have been evaluated as very important for exploration and development works. Based on them the possibility of following their extension was achieved. Hundred fifty-one have been non-mineralised anomalies; but they are caused by particular rocks, tectonic faults, and topographic effects or by the change of the thickness of the deluvion.

Based on these integrated geological-geophysical studies, industrially useful bodies (or deposits) were discovered in Ternove, Liqeni i Sopeve, 10 Korriku, Lugu i Gjate, Jugu i Batres (M-5 anomaly), Qafe Lame etc. Important results were achieved in other zones such as in Liqeni i

Dhive, Maja e Thekres, Kaptine, 80 Vjetori, Tri Gjepra, Bishti i Kalit etc.

The efficiency of geophysics is still relatively low in comparison with copper deposit exploration. By integrated geological-geophysical surveys in the 35 objects in the Bulqiza ultrabasic massif to check the anomalies have projected 356 boreholes. From these boreholes, 145 have discovered chromite ores, and 211 have been negative. The ratio of the success was 1/1,4. Many studies must performed before can be reached proper results for chrome exploration.

a) <u>Ore anomalies</u>

Geophysical anomalies caused by ore bodies have been observed in several areas.

Over the ore bodies, weak gravity anomalies are observed, with amplitude, about 0,1-0,2 mGal. These anomalies are more evident after the field transformation (fig. 4-7, 4-9, 4-10). In the gravity Bouguer anomaly map doest not present visible anomalies. After the recalculation have been prepared residual gravity anomaly map. In this map, are observed an anomaly over the chromite ore body Nr. 6 (anomaly No. I). Some others anomalies at northeastern direction are evidenced (fig. 4-2). In the exploration line III over the anomaly No. II have been projected drilling of three boreholes to check this gravity anomaly (fig. 4-3). There is observed also a complicated magnetic anomaly. All three boreholes have discovered two chromite ore bodies (fig. 4-3). In Kami deposit, are observed some negative magnetic anomalies with amplitude –700 nT over the outcrop of the massive ore body (fig. 4-5). Fig. 4-6 show weak negative anomaly that is observed over disseminates chromite ore body.

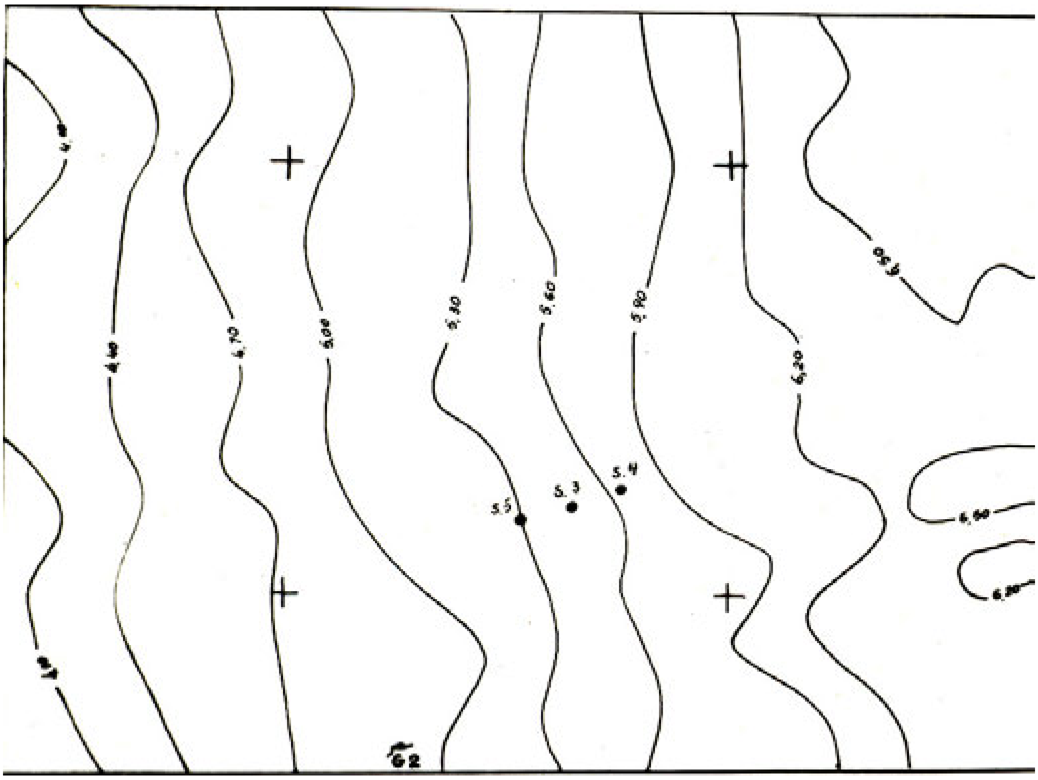

Fig. 4-1. Gravity Bouguer anomalies map, Kami deposit, and boreholes projected to check residual gravity anomaly. Iso-anomalies every 0,3 mGal. (Mihajllovsky Ja.M. 1960).

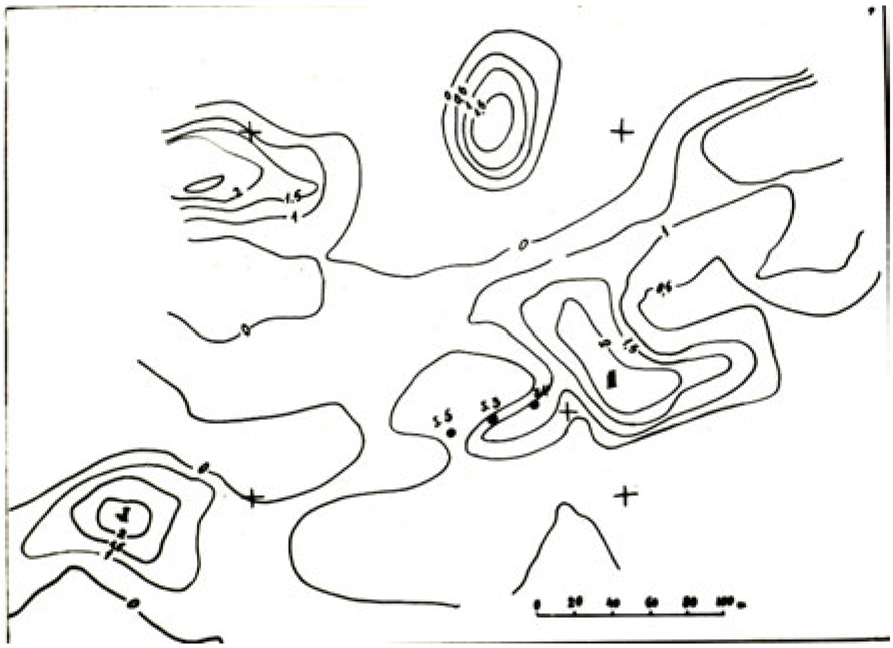

Fig. 4-2. Gravity residual anomalies map, Kami deposit, and boreholes projected to check residual gravity anomaly. Iso-anomalies every 0,5x10^{-8} mGal/cm. (Lubonja L. et al. 1973).

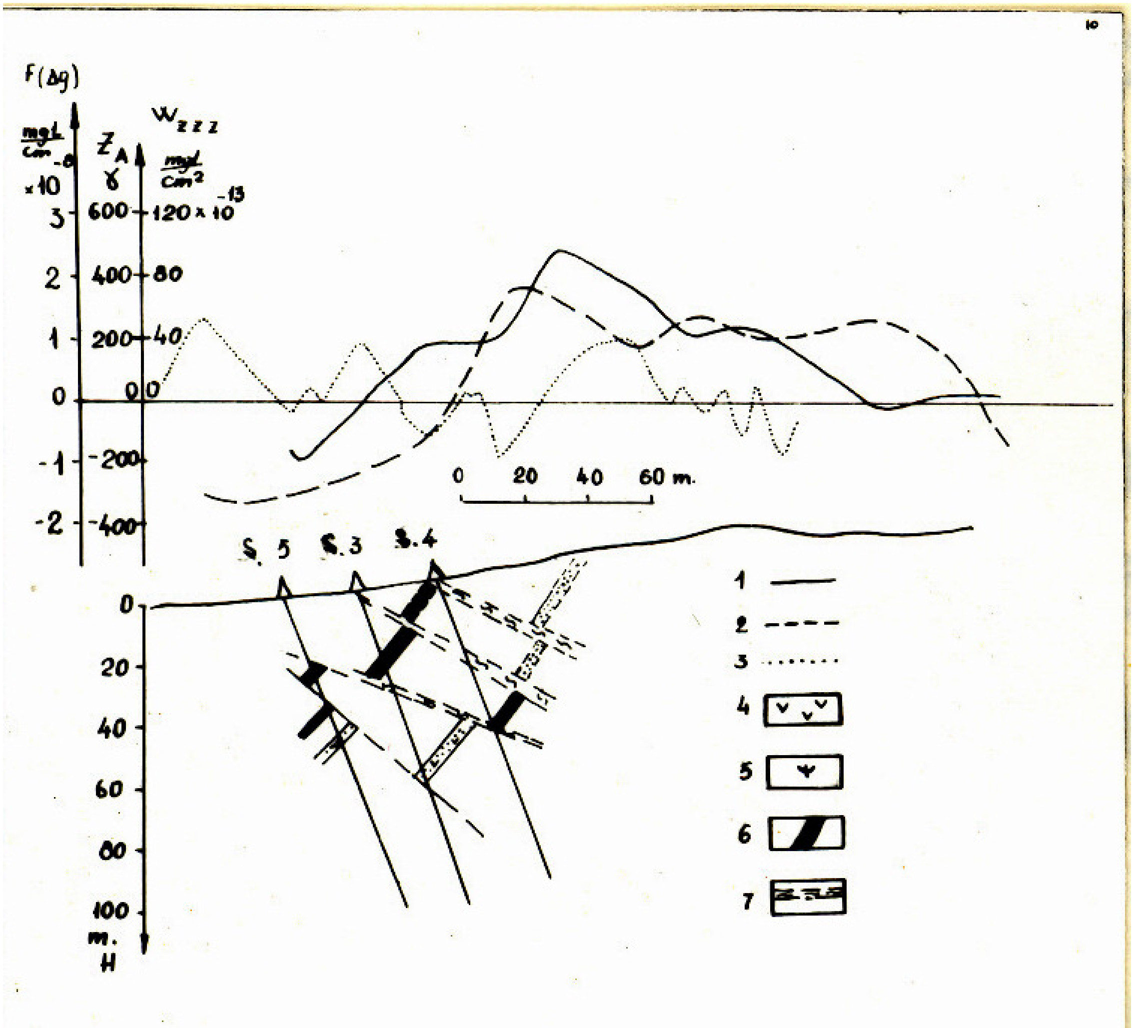

Fig. 4-3. Geological-geophysical section III-III for projecting of the boreholes to check the residual gravity anomaly, Kam deposit. (Lubonja L. et al. 1973).

1- W_{zzz} profile; 2- F(Δg) profile; 3- ΔZ profile; 4- Dunites; 5- Harcburgites; 6- chromite ore body discovered by projected boreholes; 7- Disjunctive tectonics.

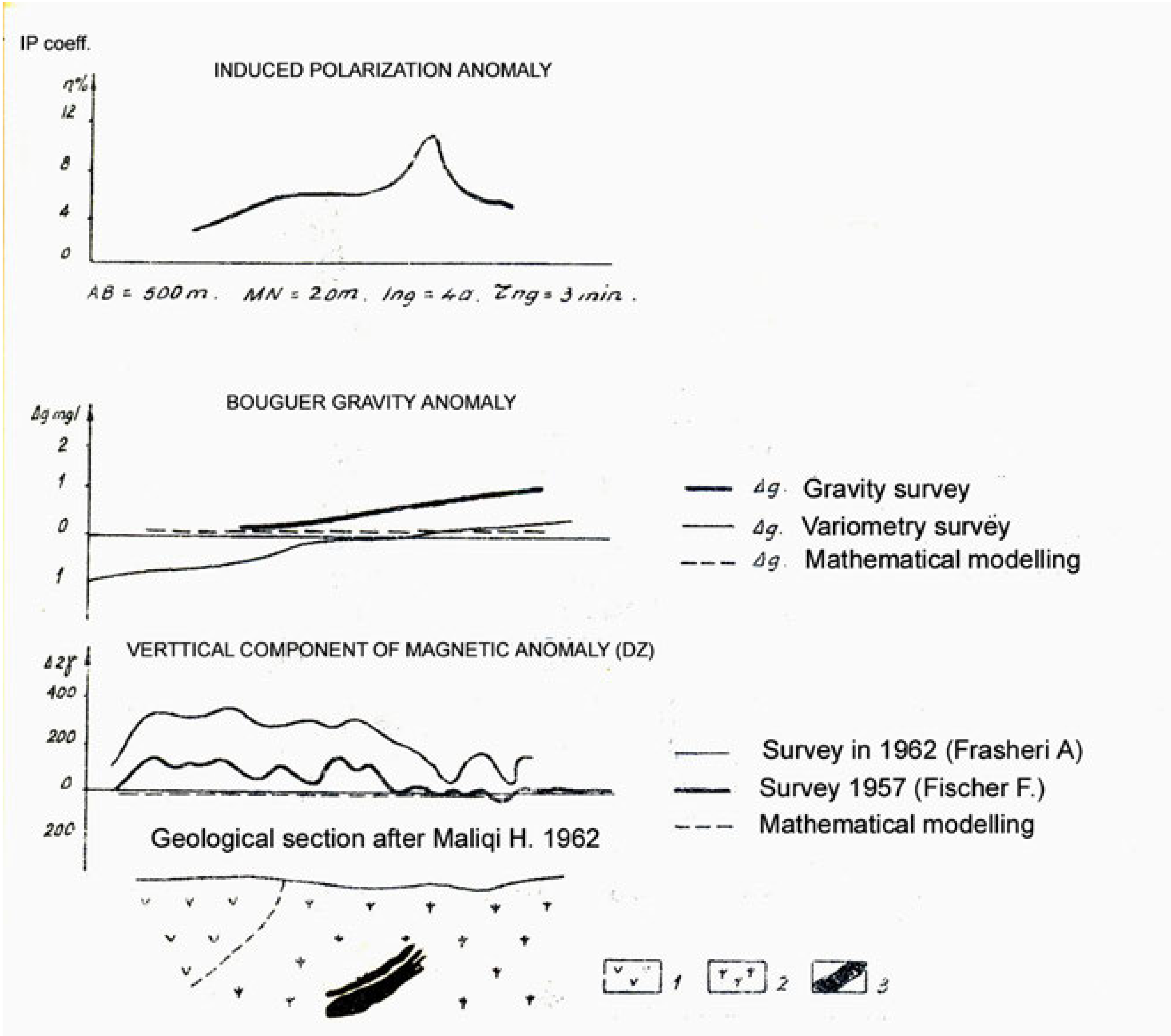

Fig. 4-4. Geological-geophysical section, Kami chromite deposit,
Tropoja ultrabasic massif. (Frasheri A. et al. 1971).
1- Peridotites; 2- Dunites; 3- Chrome spinel ore body.

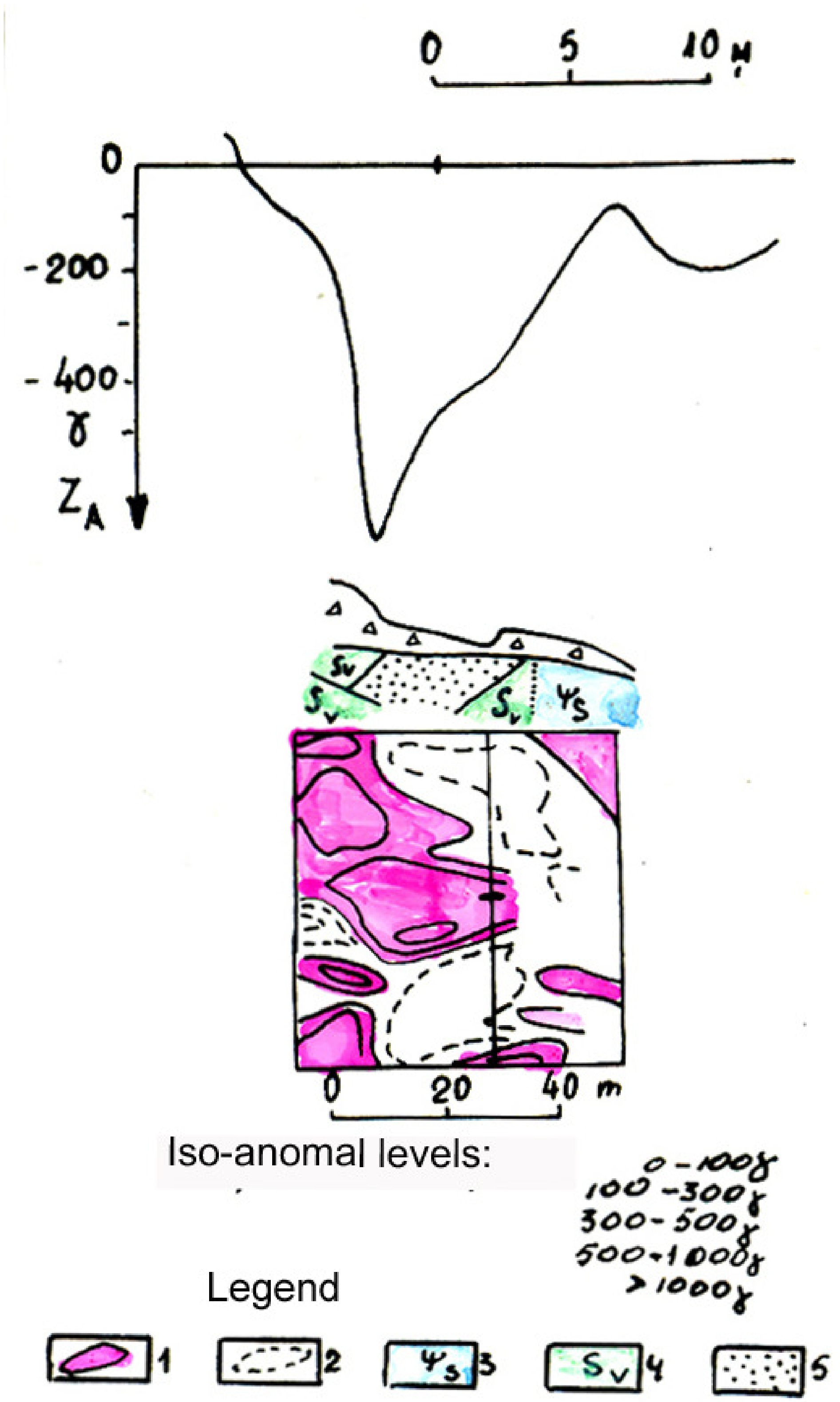

Fig. 4-5. Magnetic anomaly (ΔZ), over chromite body, Kami deposit. (Fischer F., 1957)
ΔZ<0; 2- ΔZ>0; 3- Hartzburgite; 4- Serpentinite from dunites; 5- Chromite ore body.

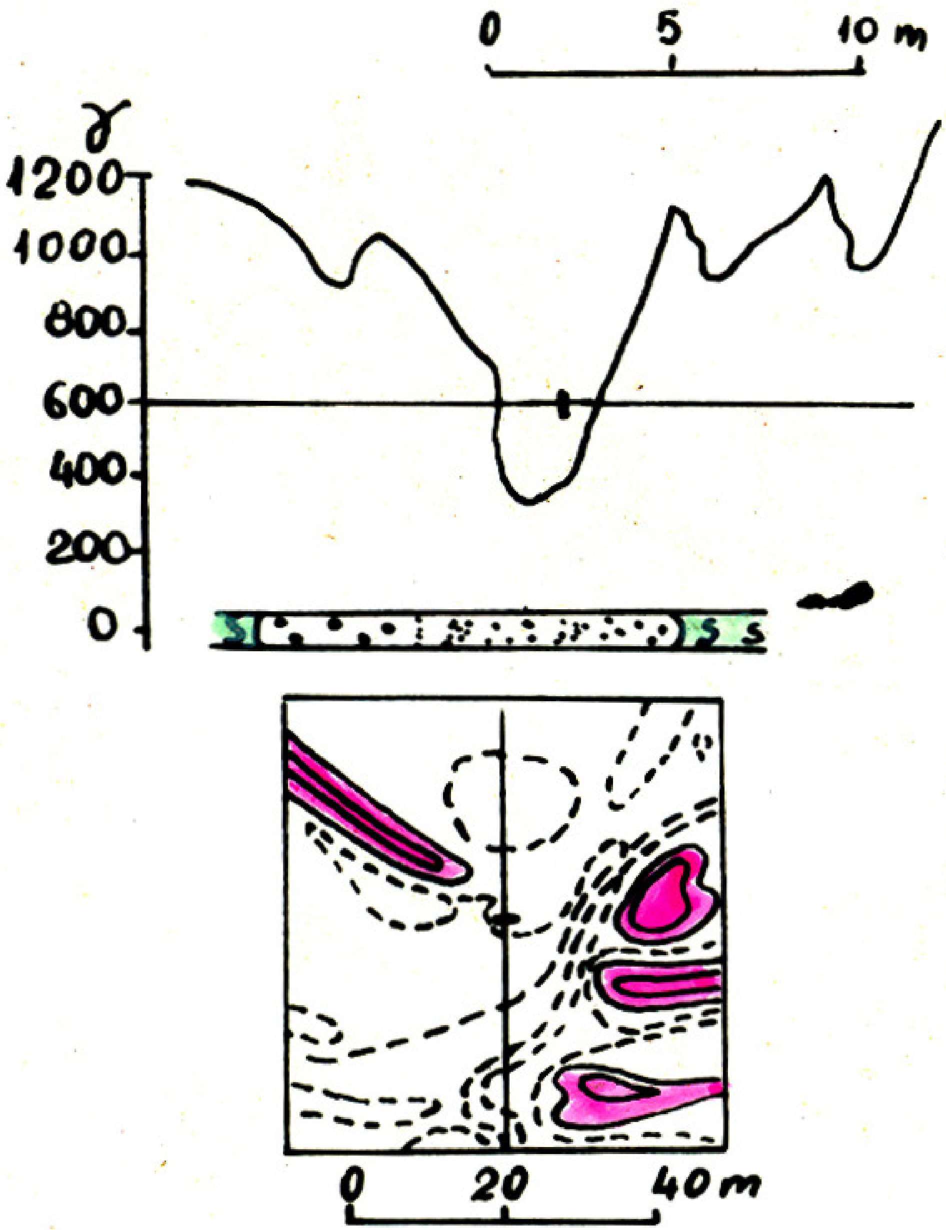

Fig. 4-6. Weak magnetic anomaly (ΔZ), over a chromite disseminates ore body (Fischer F., 1957).
Legend: as in the fig. 4-5.

The gravitational anomaly is expressed in the Bouguer anomaly graph but it is better expressed in the residual gravity anomaly calculated by Saxov-Nygard formula F (Δg) and in the residual local anomaly (Δg) plots. In this cross section, the gravitational and magnetic anomalies were fixed not only on the ore body but also around it.

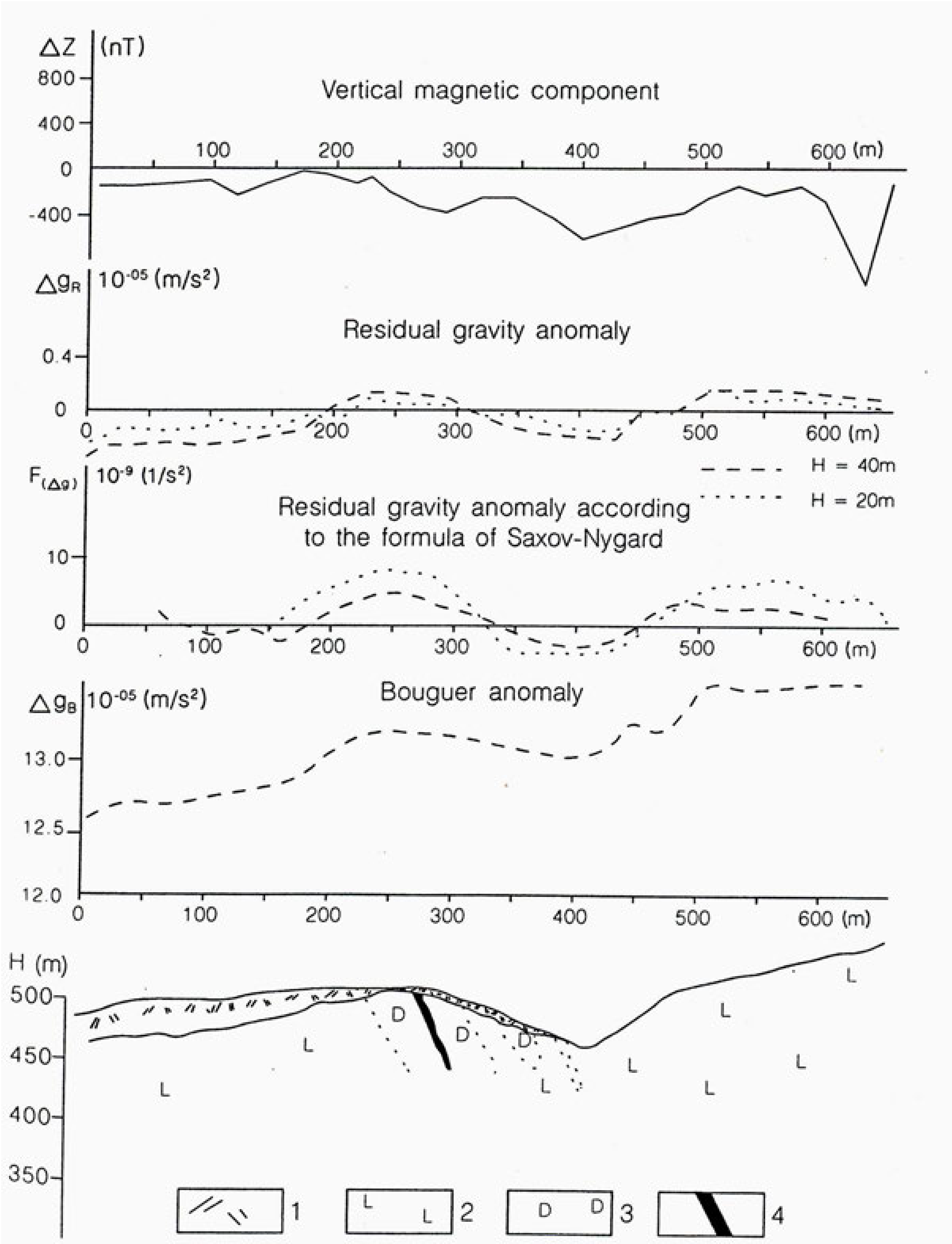

Fig. 4-7. Gravity and magnetic anomalies, Kepeneku deposit in Tropoja ultrabsic massif. (Lubonja L. and Kosho P. 1974). 1- Overburden; 2- Harzburgite; 3- Dunites; 4- Chromite ore body.

In fig. 4-8 is presented a weak negative magnetic anomalies are observed over disseminates chromite ore body No. 4 in Kepenek deposit.

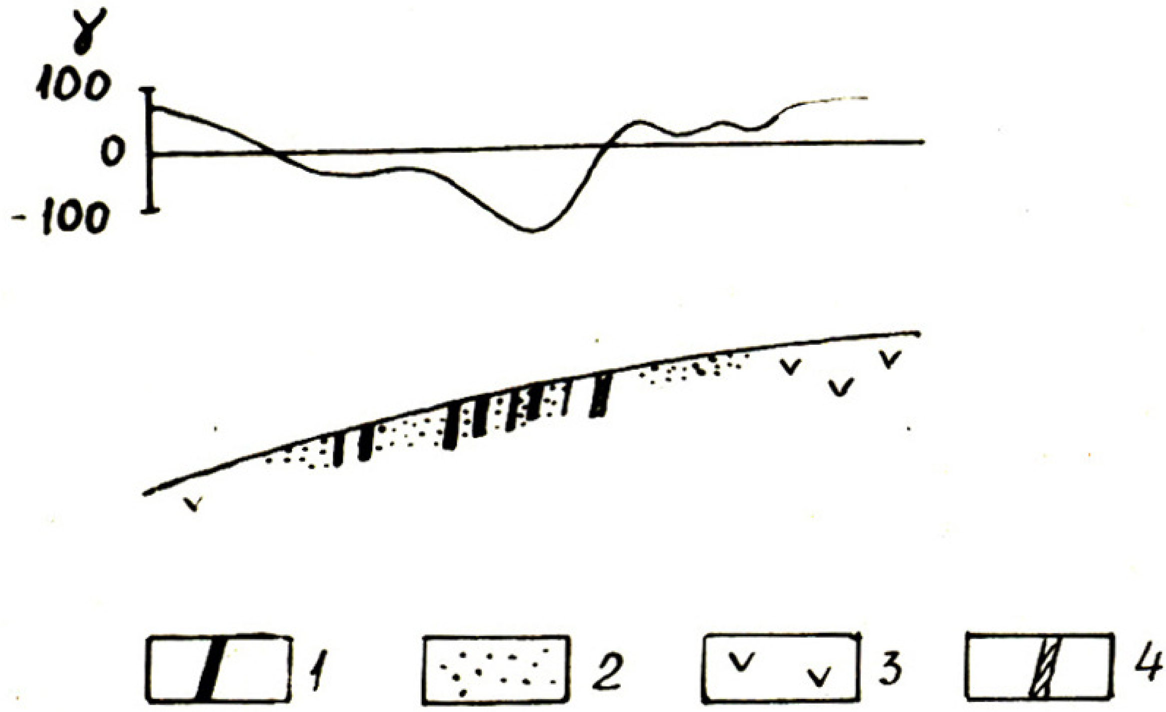

Fig. 4-8. Magnetic anomaly (ΔZ) over chromite ore body No.4, Kepenek deposit. (Fischer F., 1957)
1- Massive chromite ore; 2- Disseminates chromite ore; 3- Dunites; 4- Disjunctive tectonics.

Field transformation of Bouguer gravity anomalies (Δg) in vertical derivatives of second (W_{zz}) and thirty (W_{zzz}) orders of the gravity field potential in the Krasta and Surroi deposits have presented the anomalies with greater amplitudes (fig. 4-9, 4-10).

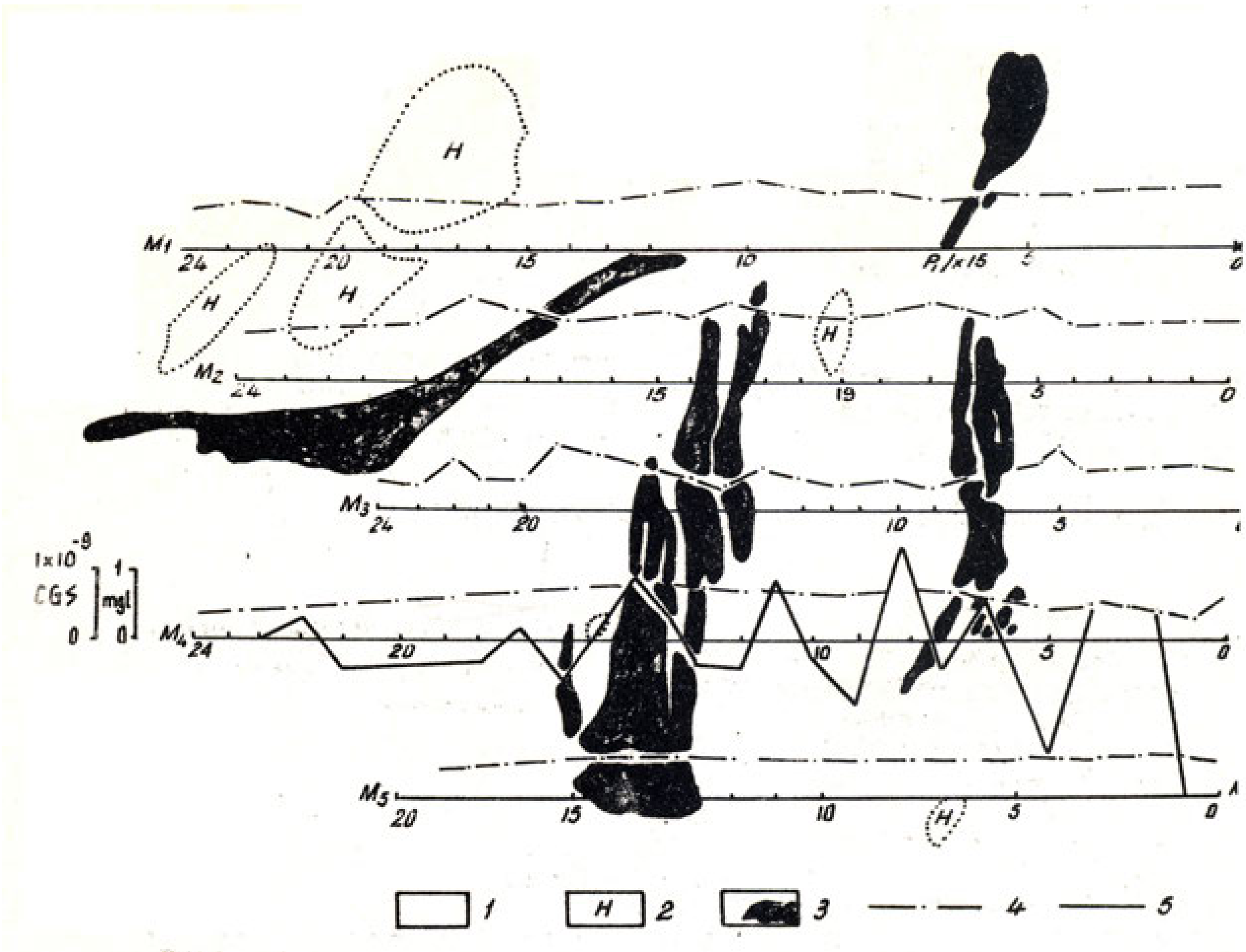

Fig. 4-9. Map of the Bouguer gravity anomalies (Δg) transformation in vertical derivatives of second and thirty orders W_{zzz} gravity field potential in M-4 line, Krasta deposit, Bulqiza ultrabasic massif (Lubonja L. & Frasheri A. 1976).
1- Dunites; 2- Hartzburgites; 3- Chromite ore body; 4- (Δg) profils; 5- W_{zzz} profils.

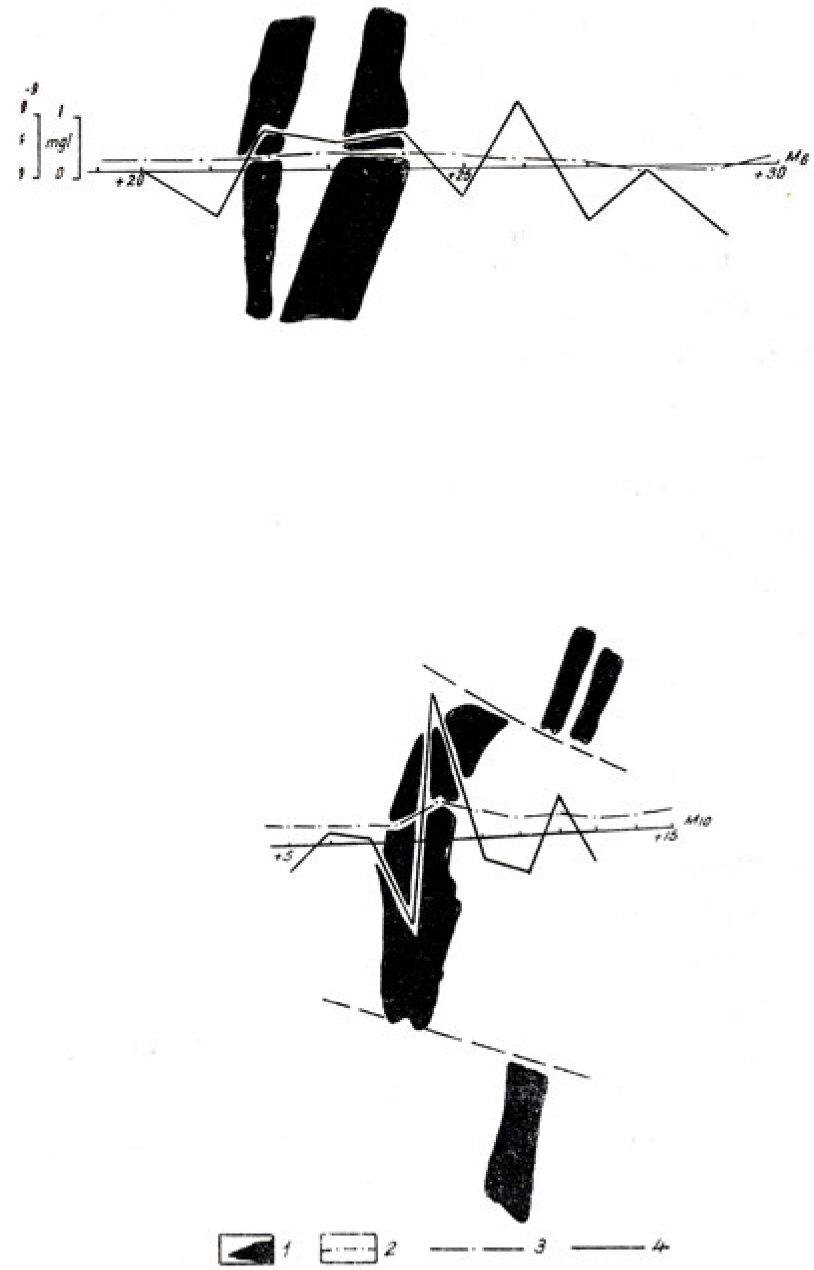

Fig. 4-10. Map of the Bouguer gravity anomalies (Δg) transformation in vertical derivatives of second and thirty orders W_{zzz} of gravity field potential, Surroi deposit, Kukesi ultrabasic massif (Lubonja L. & Frasheri A. 19676).
1- Chromite ore body; 2- disjunctive tectonics; 3- (Δg) profil; 5- W_{zzz} profil.

In the W_{zzz} graphics can detect not only ore bodies, but their apophyses, too. Such transformations are created possibilities not only to amplify weak Bouguer anomalies, but also to select

superimposed anomalies over bodies, which are located near each other.

Transformations of the Δg anomalies in vertical gradients of the gravity potential W_{zz} and W_{zzz} must not create the wrong impression that through recalculations is possible to get anomalies even in the cases where there are no Δg anomalies over the chromite body. Transformations and recalculation of the W_{zz} and W_{zzz} only may show up some peculiarities of the Bouguer gravity anomalies map and in the same time diminish and eliminate some peculiarities that don't permit to read the map.

The distribution of the magnetic field in the Kami deposit is turbulent. With great attention has been possible to select the anomalies over the chromite ore bodies (fig. 4-5, fig. 4-6). Ore body Nr.6 of the Kami deposit has created very clear IP anomaly (fig. 4-4)/

Figs. 4-11 and 4-12 shows the result of the geophysical exploration in the Tërnova deposit in the tectonic sequence, Bulqiza ultrabasic massif.

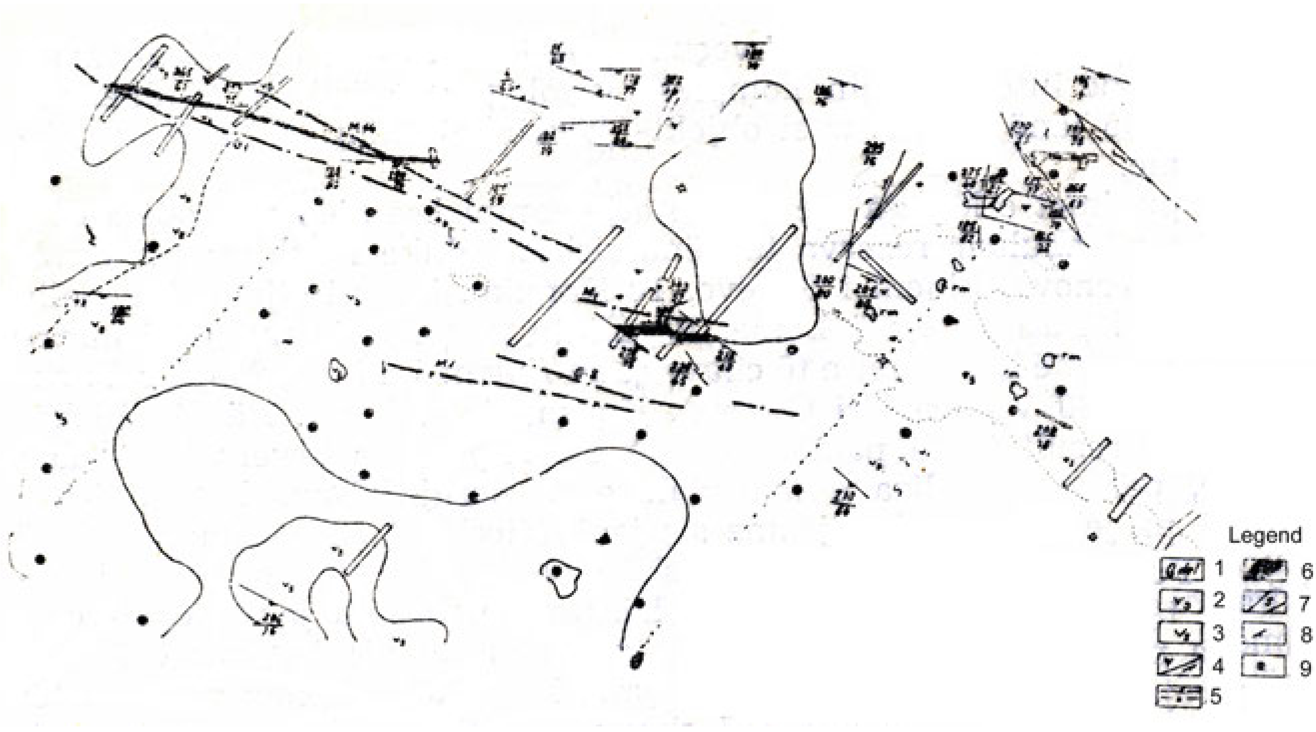

Fig. 4-11. Integrated geological-geophysical map of Tërnova deposit. (Langora Ll. et al. 1989).
1- Overburden; 2- Serpentinized dunites; 3- Serpentinized hartzburgites; 4- Pyroxenite veiny serie; 5- Gravity and magnetic anomalies; 6- Chromite ore body; 7- Serpentinized, schistized and brachiated tectonic zone; 8- Textural elements in the pyroxenite bands; 9-0 Boreholes.

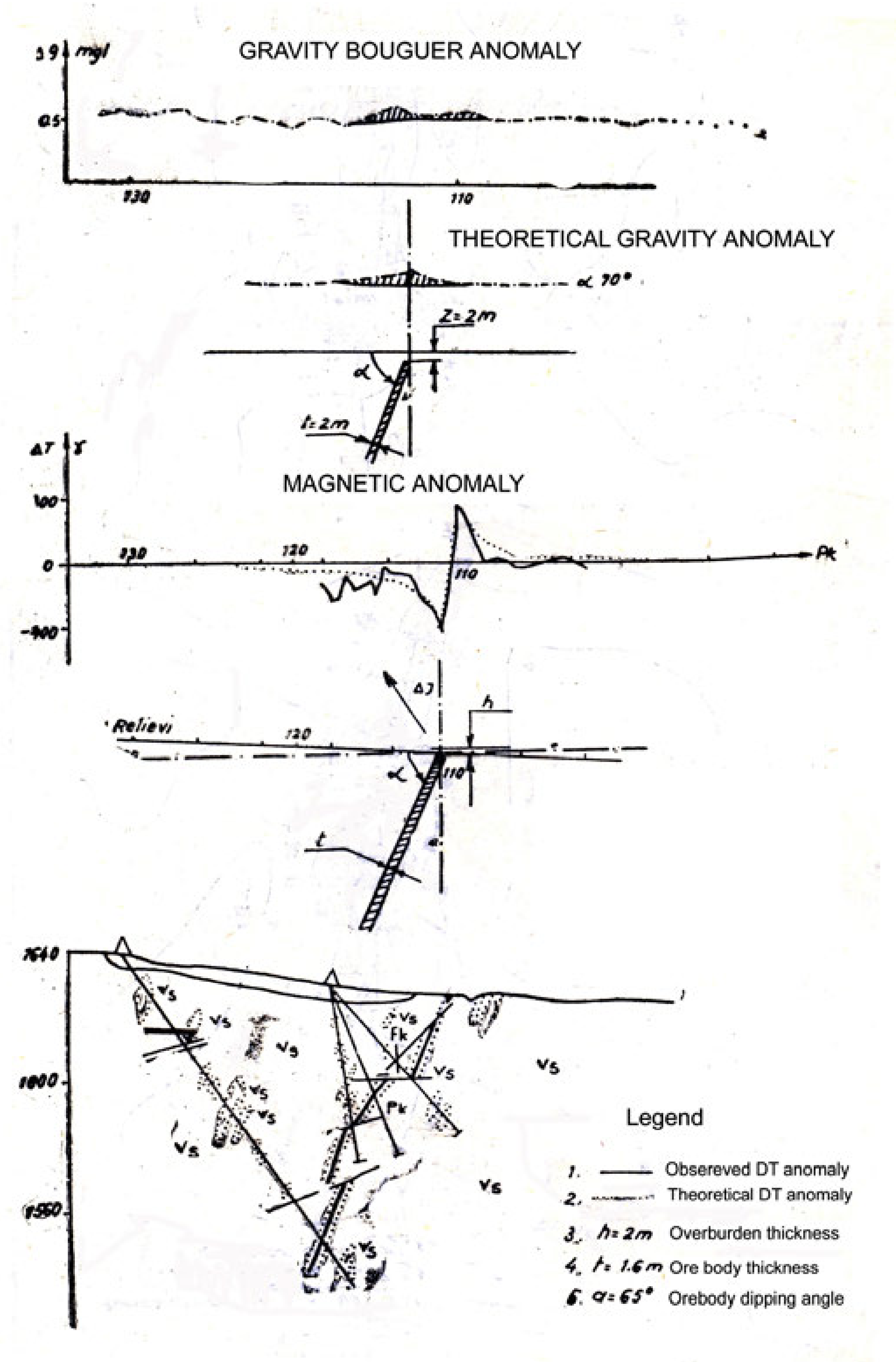

Fig. 4-12. Integrated geological-geophysical section, Tërnova deposit. (Langora Ll. et al. 1989).

1- Observed magnetic anomaly (ΔT); 2- Mathematical modelling magnetic anomaly (ΔT); 3- Overburden thickness h=2 m. ; 4- Ore body thickness t=1,6 m.; 5- Ore body dipping angle, α=65^0.

In the map, presented in the fig. 4-11, in Tërnova area are outcropped two chrome spinel occurrences. Over the northwestern occurrence were observed complex gravity and magnetic anomalies, with amplitudes respectively 0,15-0,20 Mgal and 400-600 nanoTesla. Over other outcropped body is observed only magnetic anomaly. The fig. 4-12 shows that under the overburden were discovered massive chromite ore body, with thickness about 1,6 m, and 220 m long, which presents the one of ore bodies of the Tërnova deposit.

South Batra area is characterizad by absence of chromite mineralization outcrops. In the total intensity of magnetic field (ΔT) there are observed a negative anomaly with amplitude –650 up to –670 nanto Tesla, 320 m long and 80 m width (Fig. 4-13, 4-14, 4-15).

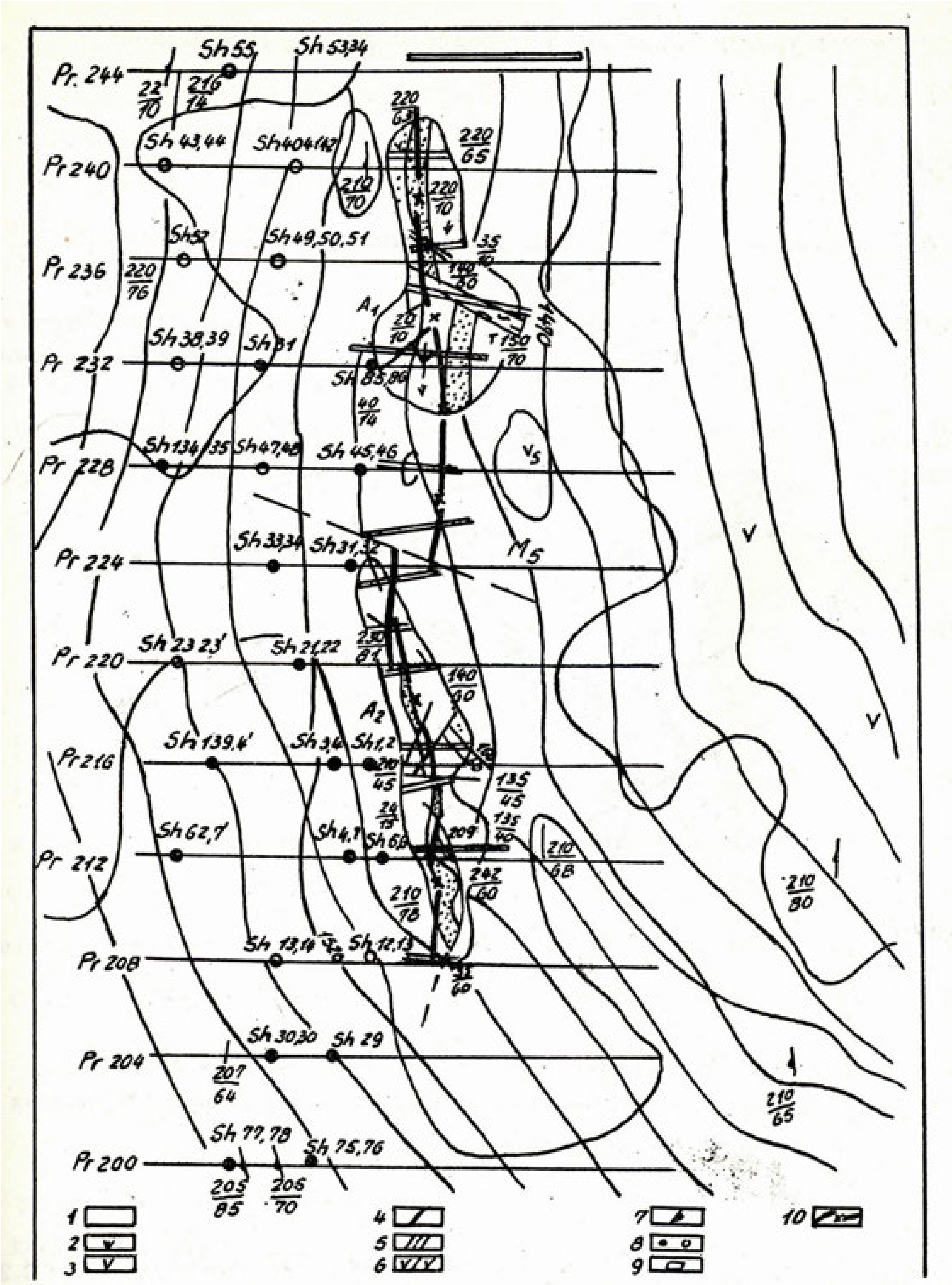

Fig. 4-13. Complex geological-magnetic map, South Batra area, Anomaly M-5. (Langora Ll. et al. 1989).

1- Overburden; 2- Serpentinized dunites; 3- Serpentinized hartzurgites; 4- Pyroxenite vein serie; 5- Chrome ore body; 6- Serpentinized, schistized and brecciated tectonic zone; 7- textural elements of the pyroxene bands; 8- Boreholes; 9- Magnetic anomaly.

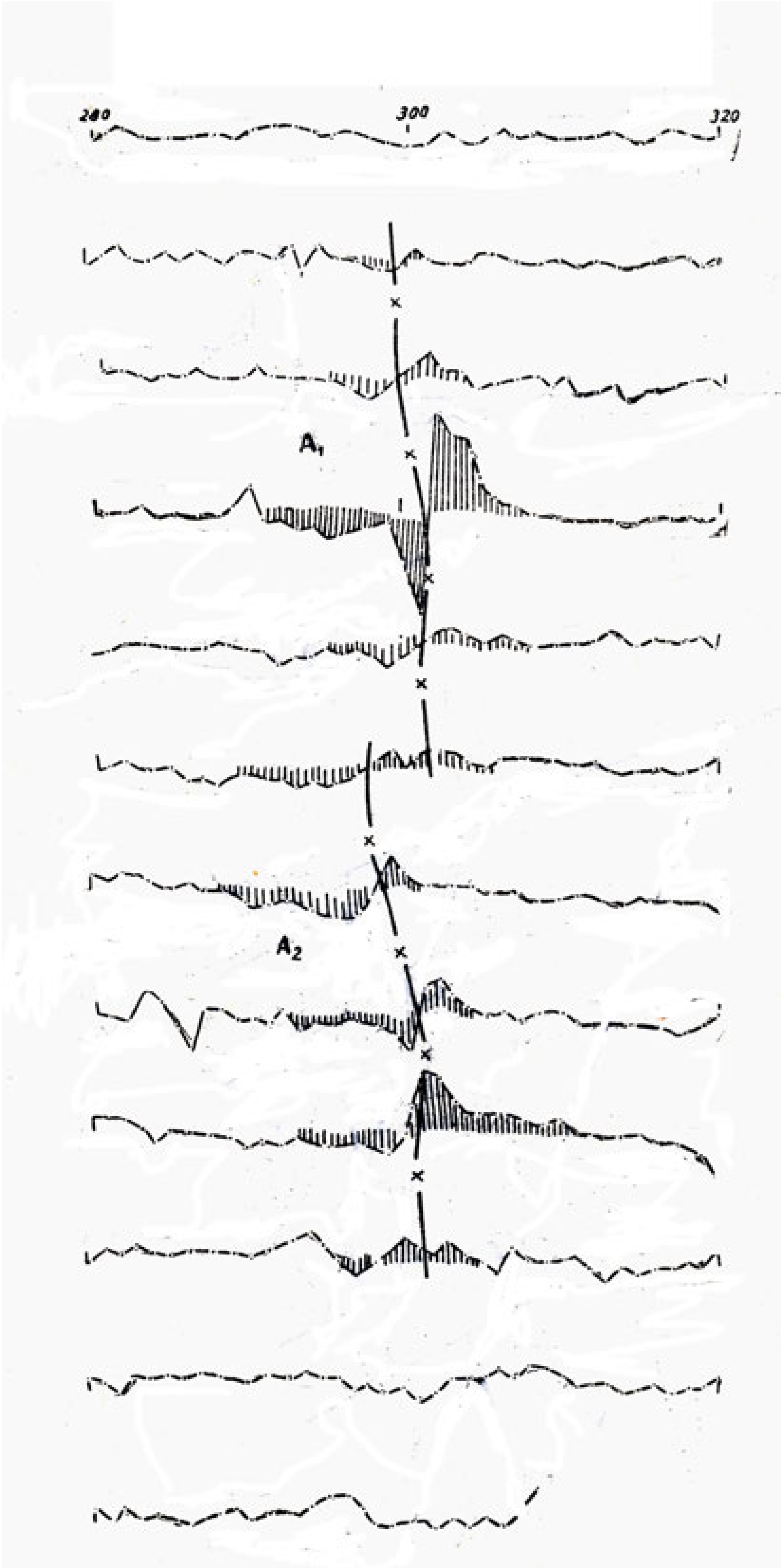

Fig. 4-14. Total intensity of magnetic field (ΔT) graphics map, South Batra area, anomaly M-5 (Langora Ll. et al. 1989).

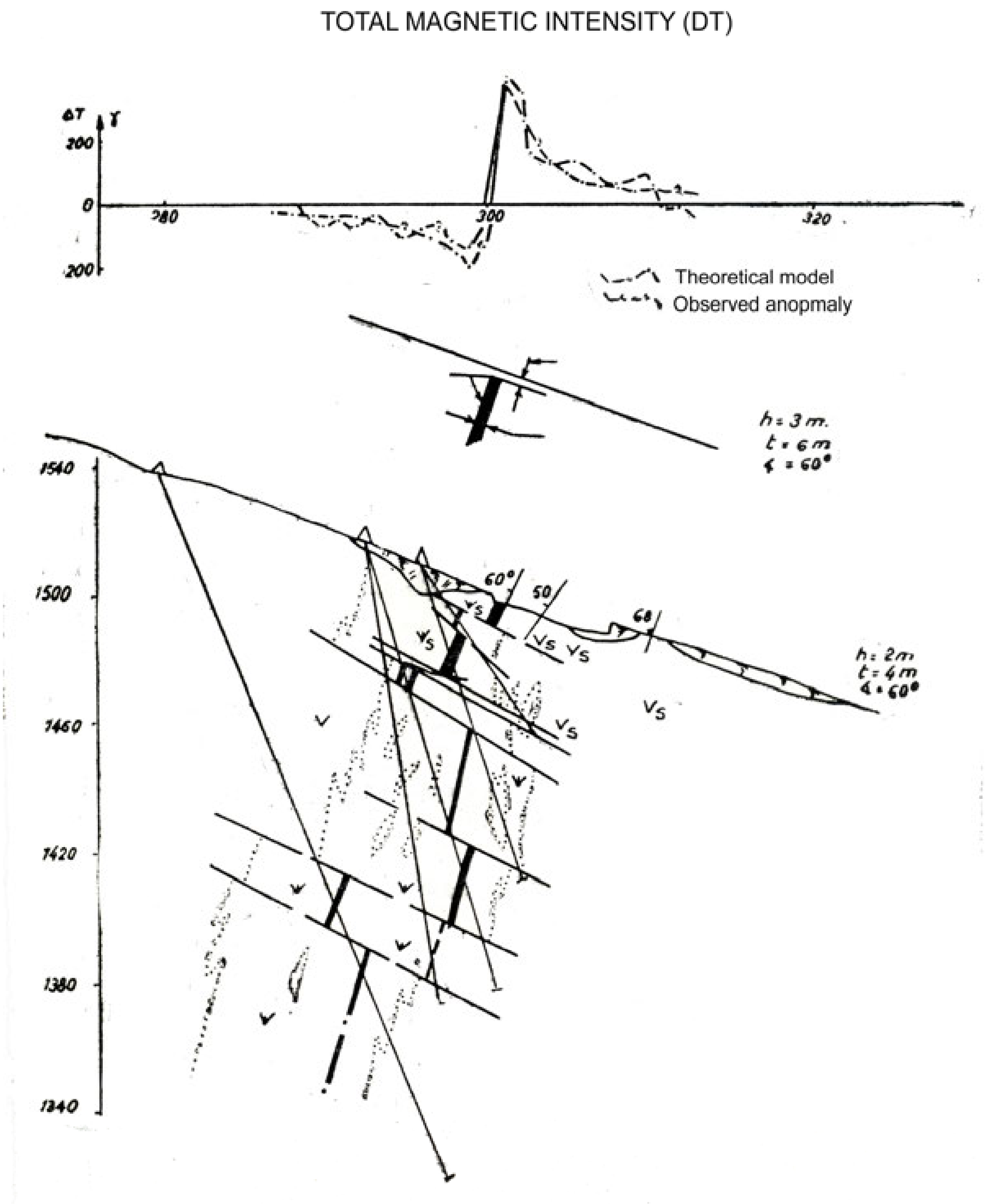

Fig. 4-15. Geological-magnetic section, South Batra area, anomaly M-5. (Langora Ll. et al. 1989).

In the case of the South Batra area, because of inverse remnant magnetization of the chrome ore body, anomaly is very complicated: anomaly presents a negative minimum together with a positive maximum (fig. 4.15). The lowest intensity values for the anomaly were

observed where the depth of the ore body was 8 m (fig. 4.15). A horizontal displacement of the extremities of the axis of an anomaly and two maximums were observed in the profile No. 224 (fig. 4.14). This anomalous behaviour can be explained by the existence of a transverse tectonic fault, which divides the body into two parts along its strike. The southern extremity of its northern part and the northern extremity of its southern part are shown in the profile No 224. That means that there were two ore bodies and consequently two maximum points.

As can be seen from the map on figure 4.13, all trenches performed to verify the anomaly, intersected ore bodies, except those presented in the profiles 224, 228. The ore bodies in the profiles No. 224 and 228 were intersected by bore holes in great depths. In the axis of this anomaly 23 bore holes and 3 galleries were projected at different topographic levels. All bore holes and galleries have intersected the ore body, which runs alongside the anomaly, with a strike about 400 m. The thickness of the body is 2-3 m and its Cr_2O_3 content reached 30-40 %. Dipping ore body has a length of 180 meters.

The search for chrome ore body in the M-5 anomaly, South Batra zone, illustrates the high effectiveness of magnetic surveying.

Intensive and wide magnetic anomalies have been observed over a chromite ore body in the Leshnica and Vlahna deposits, at Kukesi and Tropoja ultrabasic massifs (Fig. 4.16, and 4.17).

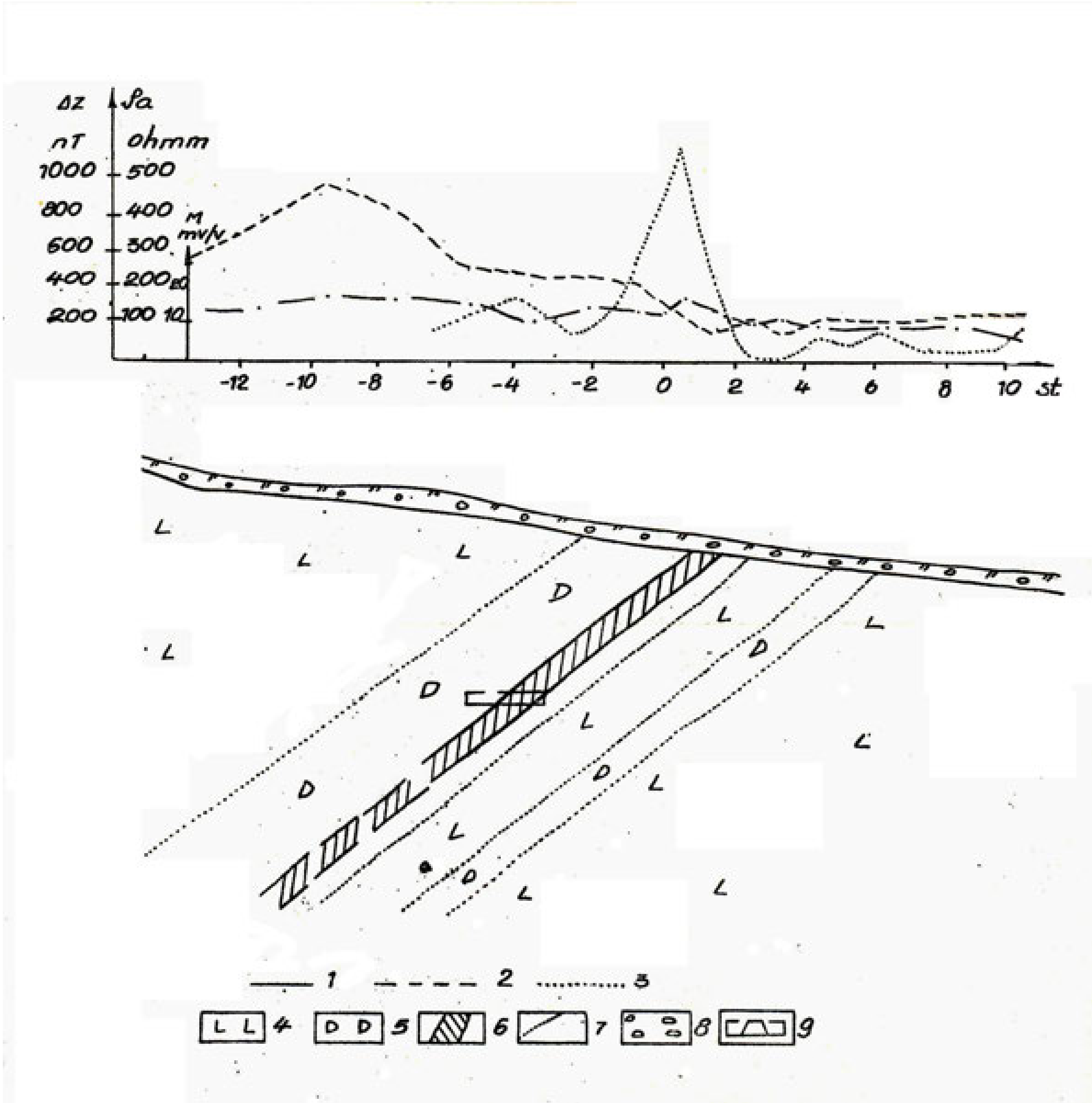

Fig. 4.16. Geological-geophysical section with a positive magnetic anomaly over a chromite ore body, Leshnice area, Kukesi ultrabasic massif (Frasheri A. et al. 1963).
1- IP coefficient profile; 2 - Apparent resistivity profile;
3 - Vertical component (DZ) of magnetic field profile; 4 – Hartzburgites; 5 – Dunites; 6 - Ore body; 7 – Gradual geological boundary; 8 – Deluvion; 9 - Gallery.

The chromite spinel ore of the Leshnica deposit is very magnetic. But, there don't existing IP anomaly. Such absence of the IP anomalies is conditioned by very high humidity of chromites, which are located in the disjunctive tectonic zone, with intensive underground water flow. In such conditions, the magnetic chromite ore is non-polarizable.

Negative magnetic anomaly of the vertical component (ΔZ) of –540 nanoTesla amplitude, and a clear IP anomaly, with amplitude of 35 - 50 mV/V, which is about 3 times over the background level, have been observed over the Vlahna chromite ore body (Tropoja massif) (fig. 4.17). Two anomalous effects superimposed this magnetic anomaly: effect from ore body over an effect from the surrounding non-magnetic serpentinites belt. Such phenomenon makes very difficult anomaly interpretation.

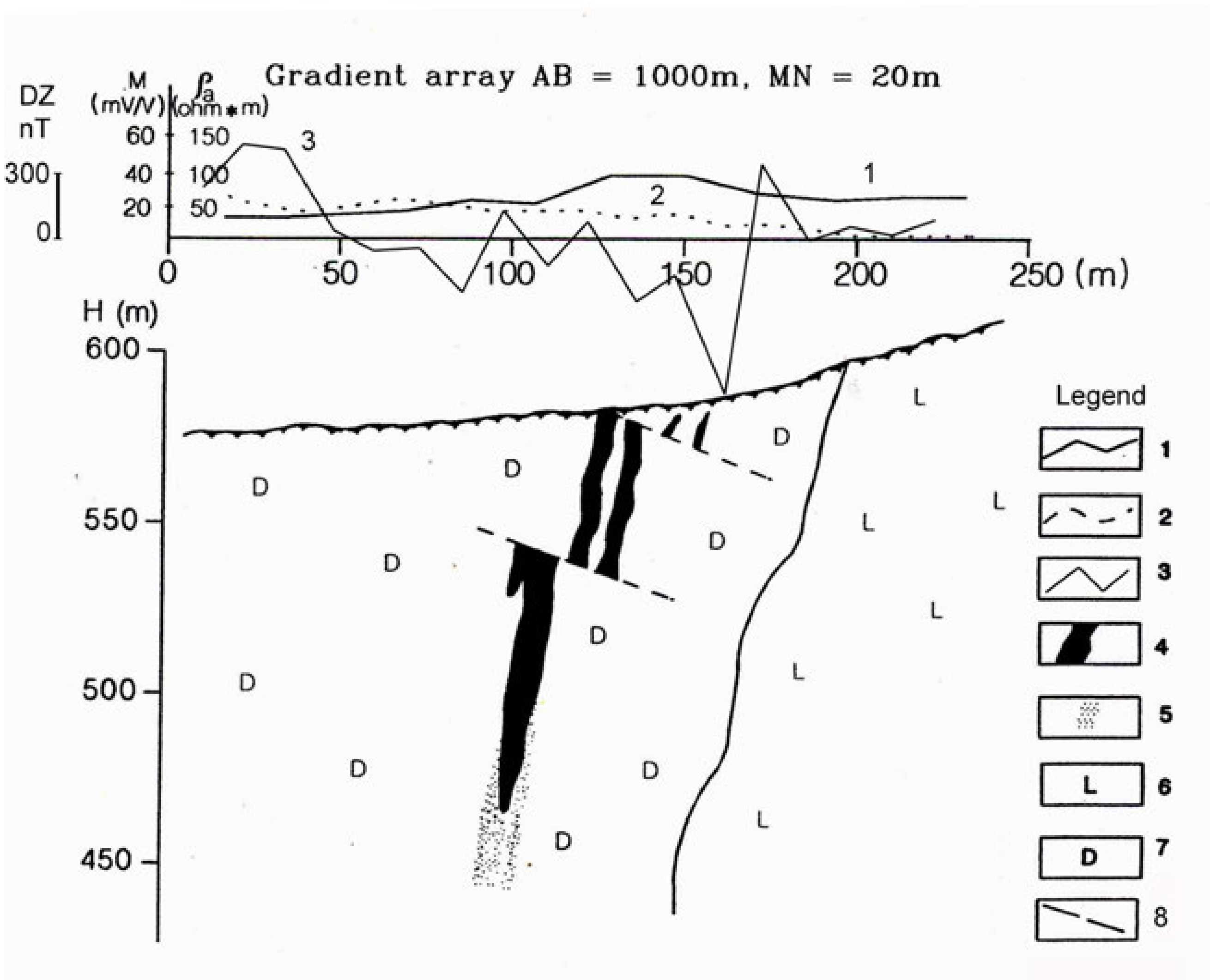

Fig. 4.17. Magnetic and IP anomalies over the Vlahna deposit (Tropoja massif) (Frasheri A. et al. 1963, Lubonja L. & Frasheri A. 1966).
1- IP coefficient profile; 2 - Apparent resistivity profile; 3- Magnetic anomaly (ΔZ); 4 – Masive chromite ore body; 5- Disseminates chromite; 5 – Hartzburgites: 6 – Dunites; 7 - Disjunctive tectonics.

In Tri Gjepra area (Bulqiza ultrabsic massif) has observed IP anomaly (fig. 4.18).

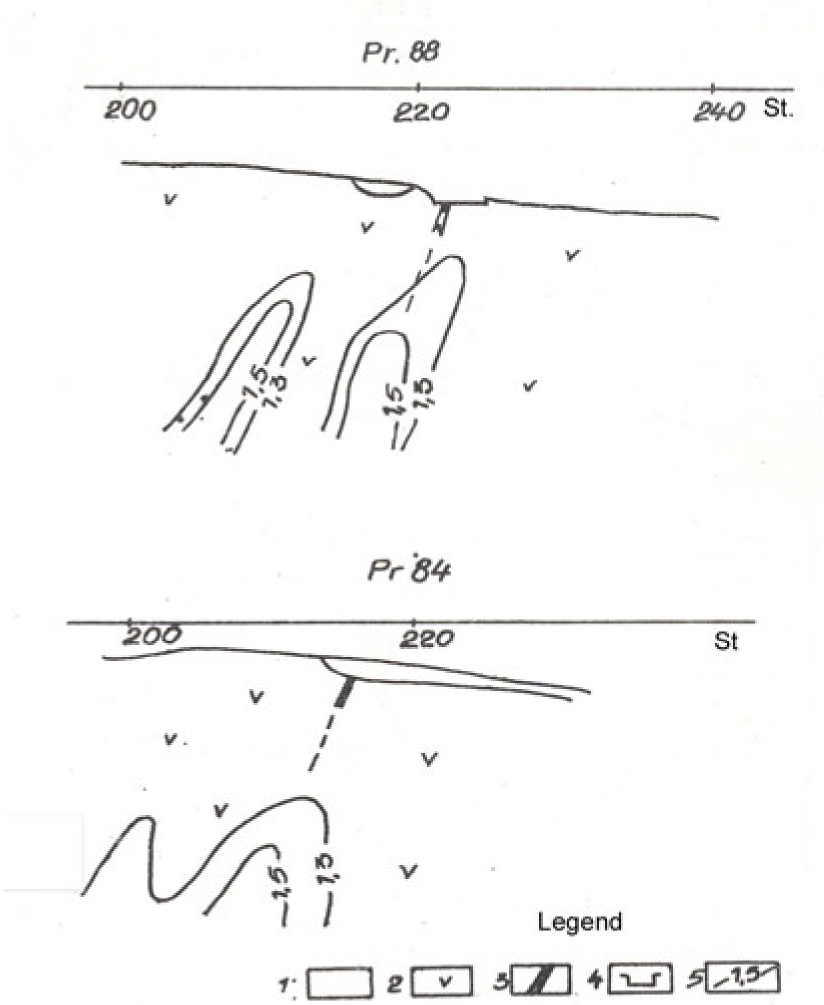

Fig. 4.18. IP real section with multiple gradient arrays in Tri Gjepra zone (Bulqiza). The arrays AB = 200, 400, 600 m; MN = 20 m, (Prenga Ll. Et al. 1986).
1 – Deluvion; 2 – Hartzburgites; 3 - Ore body; 4 – Trench; 5 - IP coefficient contours (in % units).

From the IP sections shown in fig. 4-18, can be seen that the IP anomaly is contoured by a line with value of 1.4% over the background level. This level is 1-1.2% for hartzburgites and 1.5-1.8% for dunites. The anomaly has amplitude of 1.5-2.5% at the width of 30-40m. Since the ore body layout is underneath the shallow deluvion, these anomalies can be discriminated better by using of pol dipole array A20M20N,B→∞. Many boreholes and trenches intersected this anomaly, which a length about 280 m.

The chromite ore in the Qafe Gjelas deposit in the Bulqiza massif has a predominant density value of 4000 kg/m^3, which is higher than the density of the surrounding rocks. This is a magnetic ore and has a predominant IP coefficient value of 1.7%. The dunites and hartzburgites have an IP coefficient of 0.7% and 1.2% respectively. For this reason clear gravitational, magnetic and IP anomalies have been observed over this ore body (fig. 4-19).

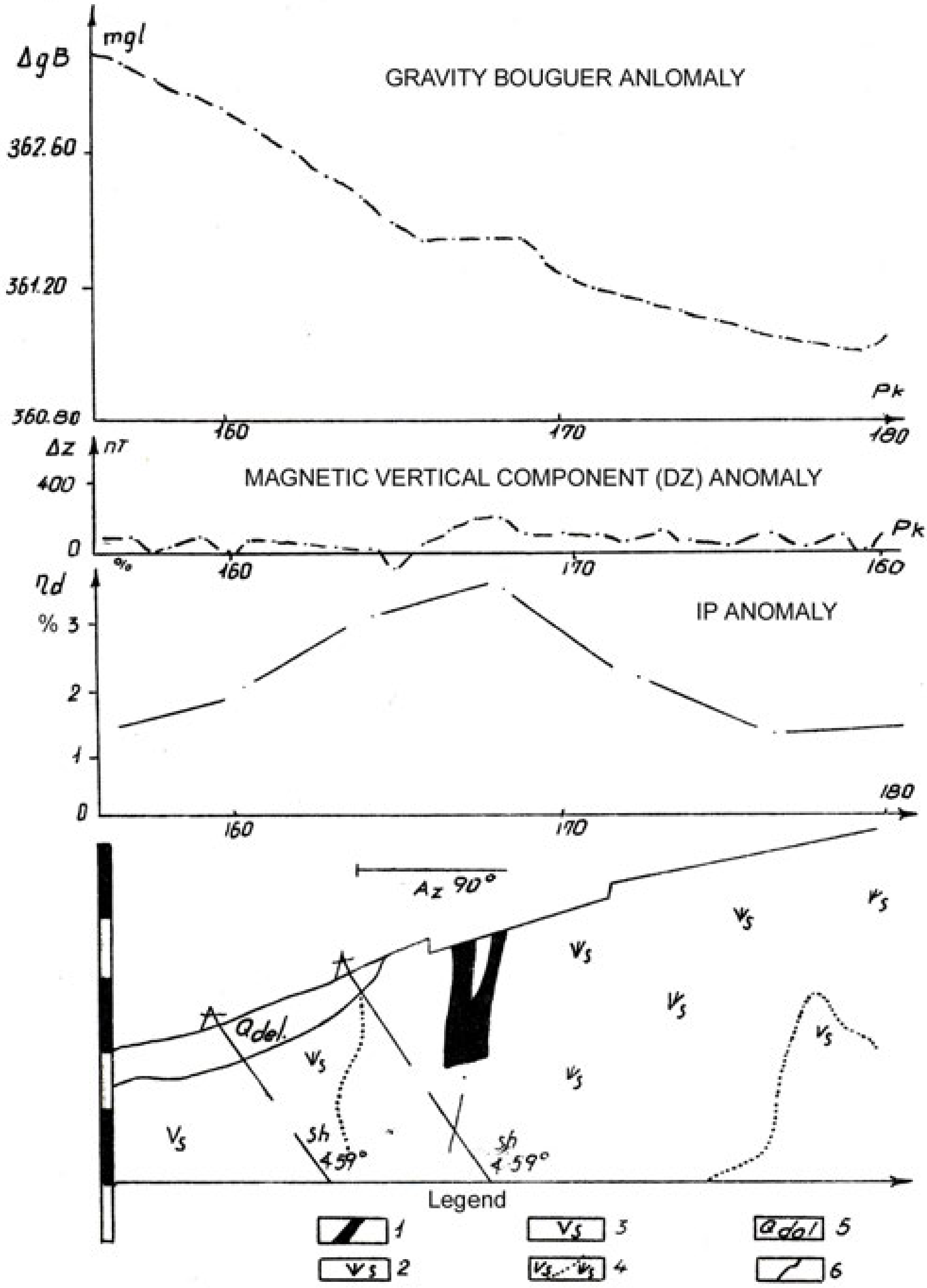

Fig. 4.19. Geological-Geophysical section in Qafe Gjela deposit (Bulqiza massif) (Prenga Ll. et al. 1983).

1 - Ore body, 2 - Serpentinized dunite, 3 - Serpentinized hartzburgite, 4 - Smooth-rock border, 5 - Deluvion, 6 - Tectonic fault.

From this section can be seen that the IP anomaly is a rather wide one. This is due to the influence of ore body and its dunite envelope (fig. 4.20). Consequently a complicated wide anomaly is observed.

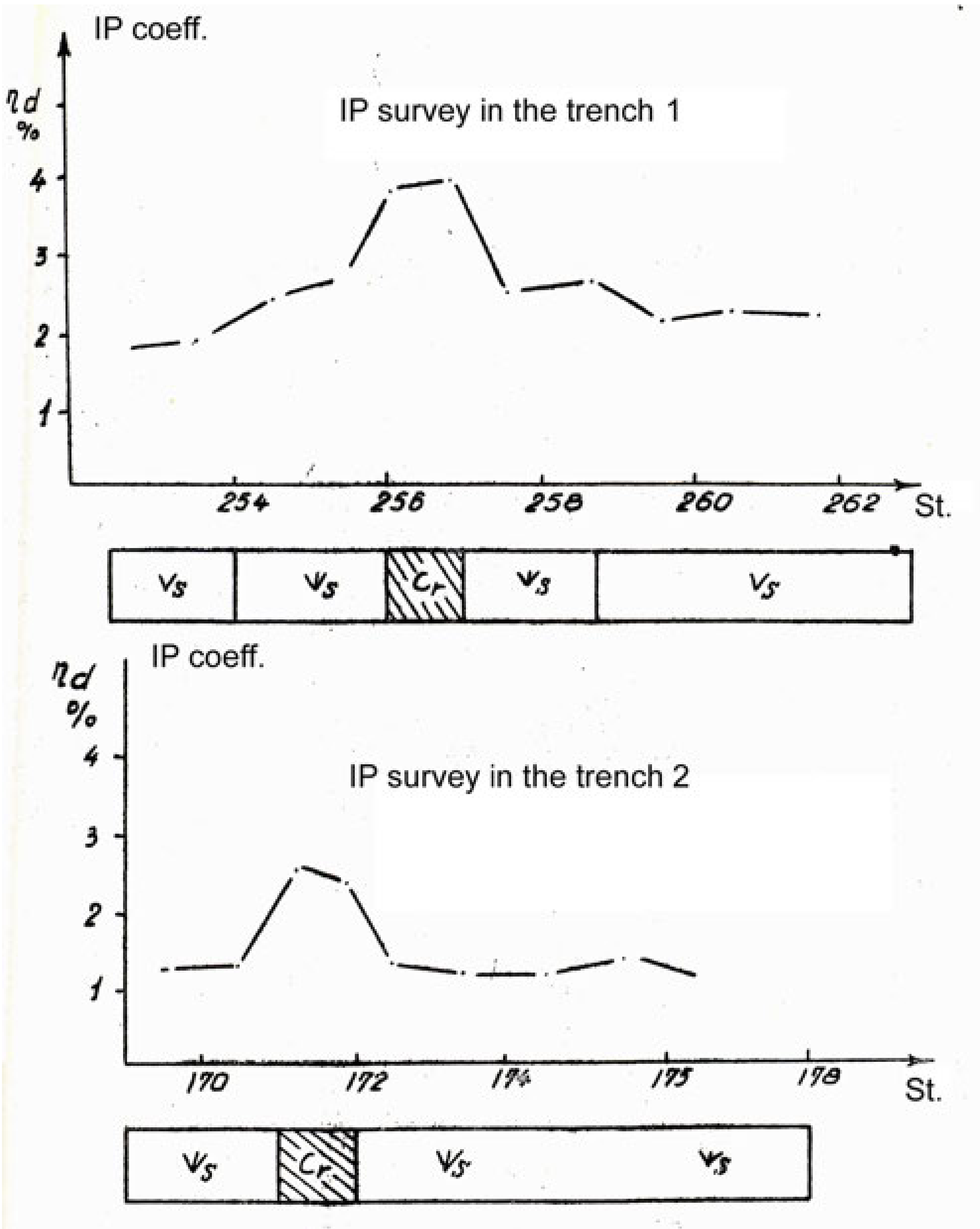

Fig. 4.20. IP anomalies according to parametric measurements over two trenches at Qafe Gjelas chrome deposit (Prenga Ll. et al. 1983).

a - Complicated anomaly over the ore body and dunitic envelope, b - Single anomaly over the ore body.

Fresh dunites and hartzburgites are extended in Tplana area. Consequently, magneti field is relatively quiet. Negative magnetic anomalies over massive chromite ore body (fig. 4-21). There are observed other negatiuve anomalies, which can be are caused by unknown ore chromite ore bodie, or over a paramagnetic gabbro-pegmatite/pyroxenite vein.

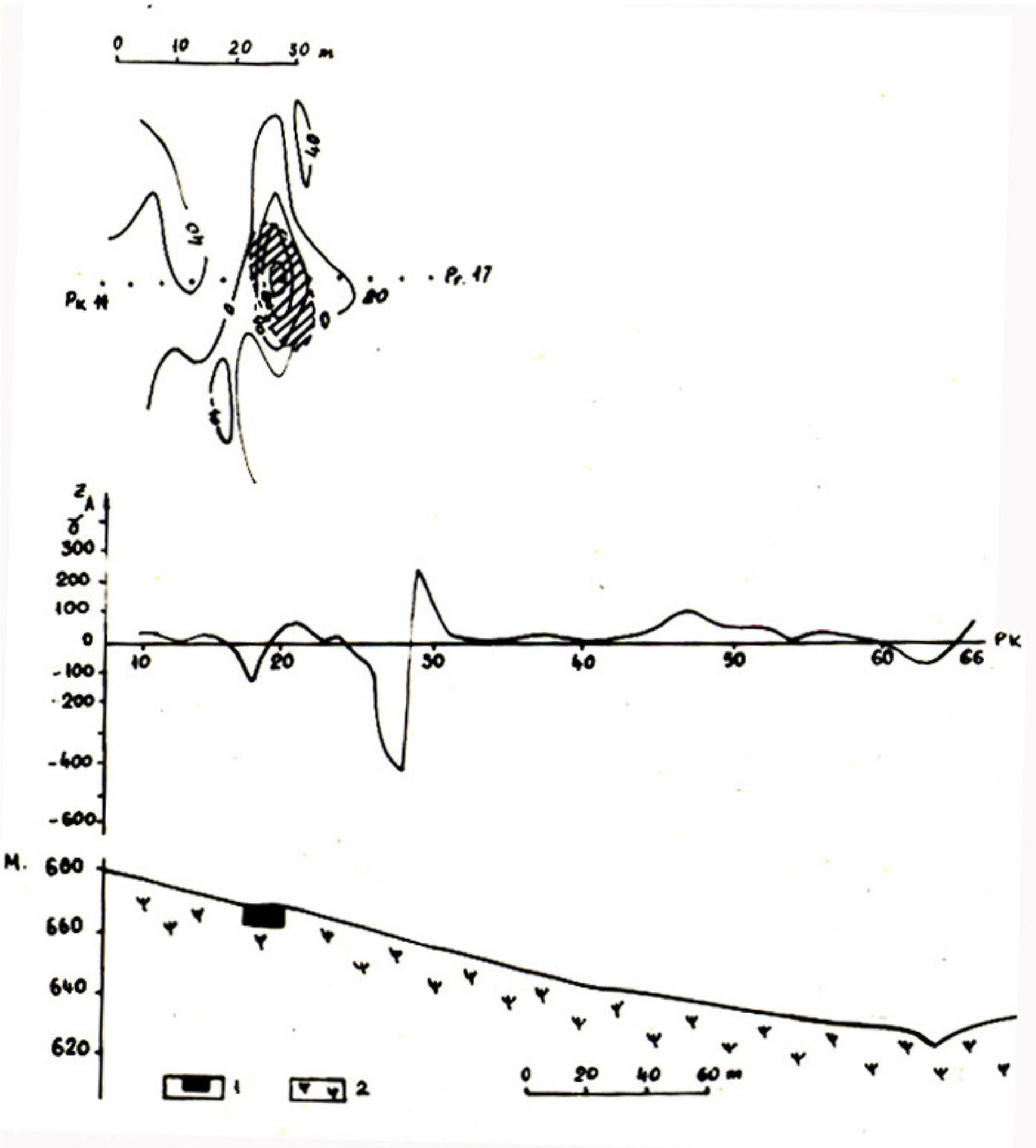

Fig. 4-21. Magnetic anomalie (ΔZ) over a chromite pore body in Tplanë area. (Frasheri A., et al. 1963).
1- Chromite ore body; 2- Hartzburgiyte.

b) Non-ore anomalies

During the geophysical mapping for the search for chrome ores, have been observed a lot of non-ore anomalies, due to many factors such as:

- Fresh rock inclusions between serpentinized rocks, which may create gravitational anomalies.
- Serpentinized rocks with high content of magnetite which can create magnetic anomalies, or indueced polarization.

For example a magnetic anomaly of the amplitude -200 and +200 nT was caused by highly serpentinized dunites (fig. 4.22). IP anomalies can be observed, in these zones, as well.

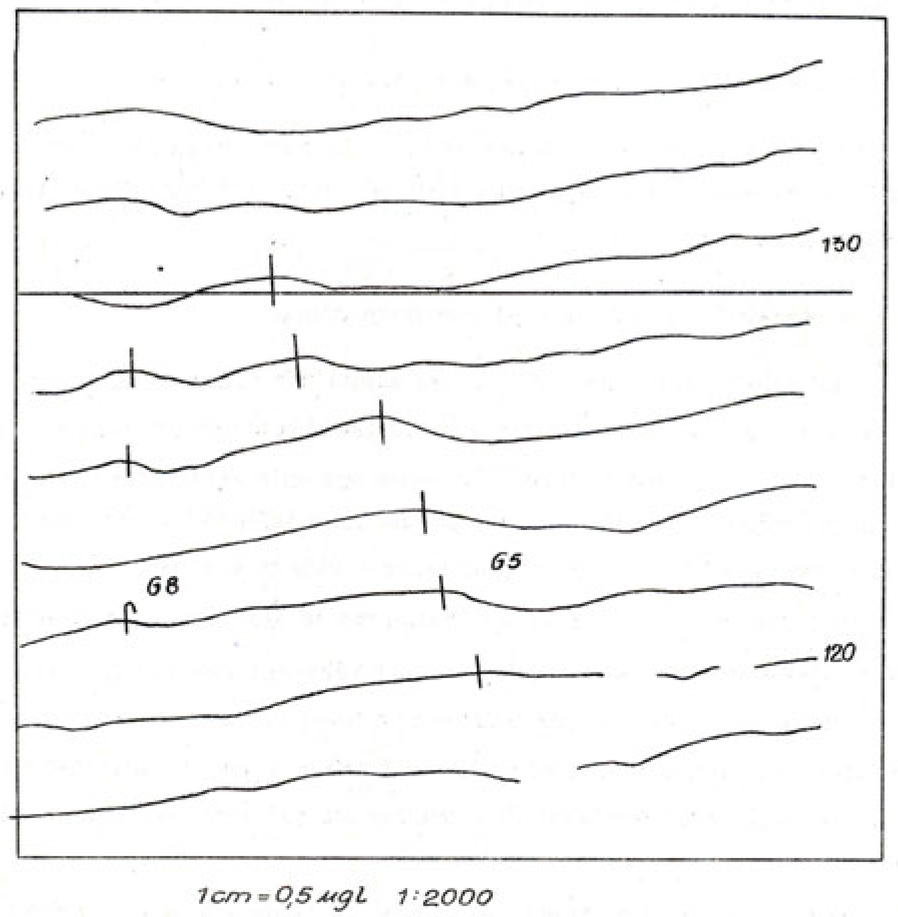

Fig. 4.22. The map of profiles of the total magnetic field intensity (ΔT) at Fushe Kalti zone (Bulqiza massif), where magnetic anomaly is observed over highly serpentinized belt and crushed dunitic inclusions have been observed (Sharra Xh., Rrenja A. et al. 1987).

Gravitational anomalies have been observed in zones with thin cover of soft overburden and compact bedrocks close to surface (fig. 4.23).

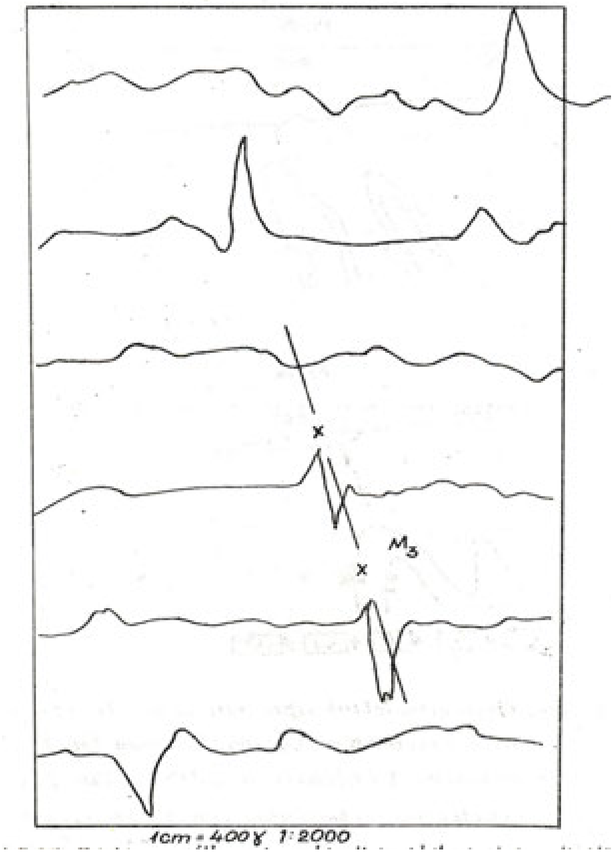

Fig. 4.23. The map of profiles of the Bouguer anomaly in Fushe Kalti (Bulqiza massif), in a sector where are decreased the thickness of the soft overburden. (According to the Sharra Xh., Rrenja A. et al. 1987).

Prior to Bouguer anomaly interpretation, the thickness of soft sediments (deluvion and eluvion) was determined by apparent resistivity soundings. The main task of the interpretation was to selected the anomalies caused by ore bodies.

Intensive negative magnetic anomalies is observed over non-magnetic rock individualizations or gabbro-pegmatites/pyroxenite dykes. Fig. 4-24 shows an anomaly with amplitude –500 nT over non-magnetic serpentinized hartzburgites and serpentinites in Kami deposit area.

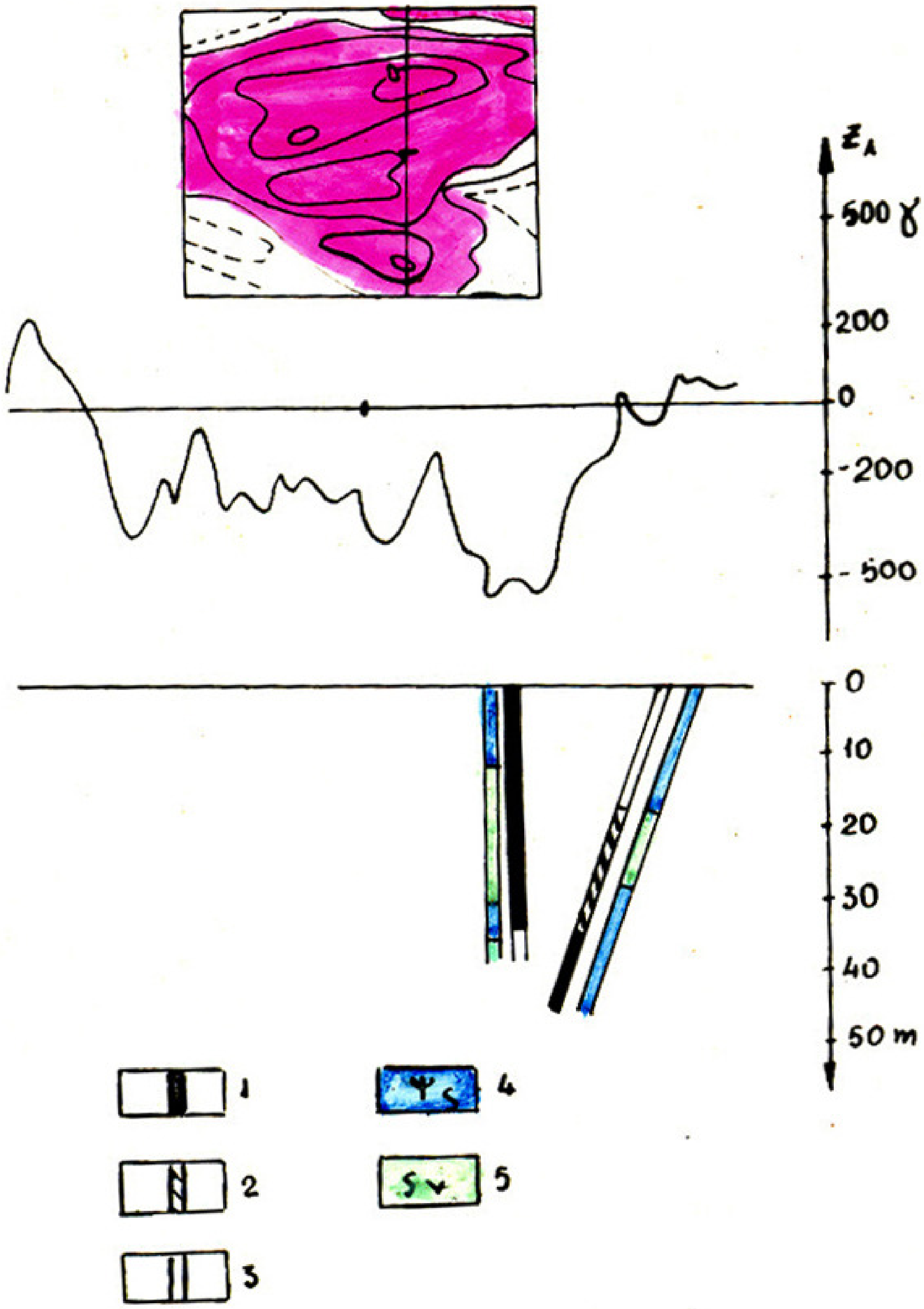

Fig. 4-24. Magnetic anomaly (ΔZ) opver non-magnetic rock individualisation, kam deposit. (Fischer F. 1957)
1- Magnetic susceptibility x=250x10-5 units SI; 2- x=350x10-5 units SI; 3- x=400x10-5 units SI; 4- Serpentinized hartzburgites; 5- Serpentinite from dunites.

A typical narrow and intensive magnetic anomaly, with amplitude of -16.000 nT is observed over a pyroxenite vein in the Kam deposit area (fig. 4-25).

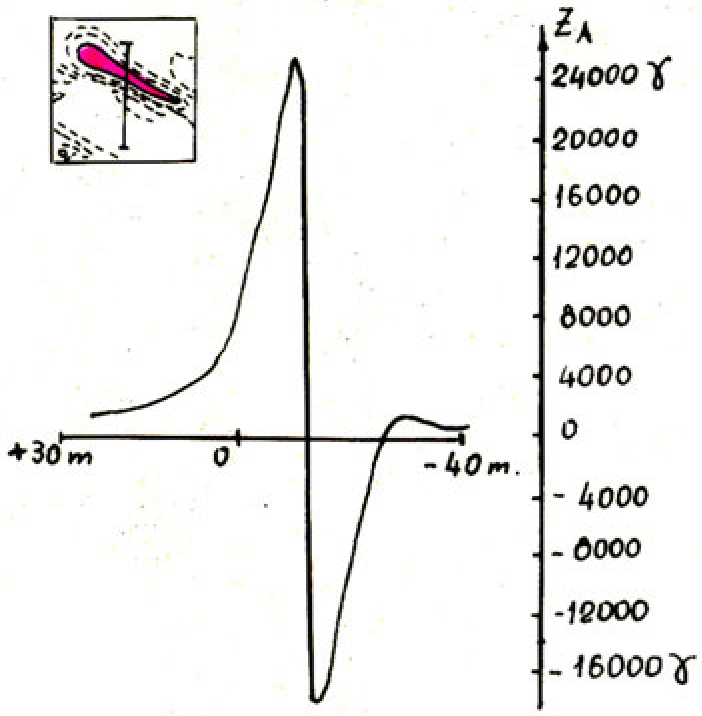

Fig. 4-25. Magnetic anomaly (ΔZ) over a pyroxenite vein, Kami deposit. (Fischer F., 1957).

4.2. Underground geophysical surveys

Underground geophysical surveys have been carried out in boreholes, in galleries and other mine works to solve the following problems:

a) <u>The search around mine works</u>

The search around mine works has been conducted in order to contour known ore bodies, especially those that are effected by tectonic faults, and to search for new ore bodies located around mine works. The goal was to increase the search depth and to get the available information for a sparse network of mine works at the first stage of the exploration.

Underground surveys can be made by all geophysical methods, which are used also by surface mapping. Radio wave floodlighting method can be used as additional ones.

The experience gained, especially during the eighty years period in Albania showed that the three components magnetic borehole method can be implemented successfully and efficiently for the search for magnetic chrome ore bodies. Typical example is presented the underground magnetic surveys in four boreholes in the Shkalla area, Bulqiza ultrabasic massif (Fig. 4-26) (Gjevreku Dh. 1984, Langora Ll. et al 1988). In the borehole No. 141 are observed two anomalies, at the depth 100 m and 140-180 m (fig. 4-17). The anomalies, respectively have an amplitudes: ΔZ=7 500 nT, ΔH=8 500 nT, and ΔZ=5000 nT, ΔH=8000 nT.

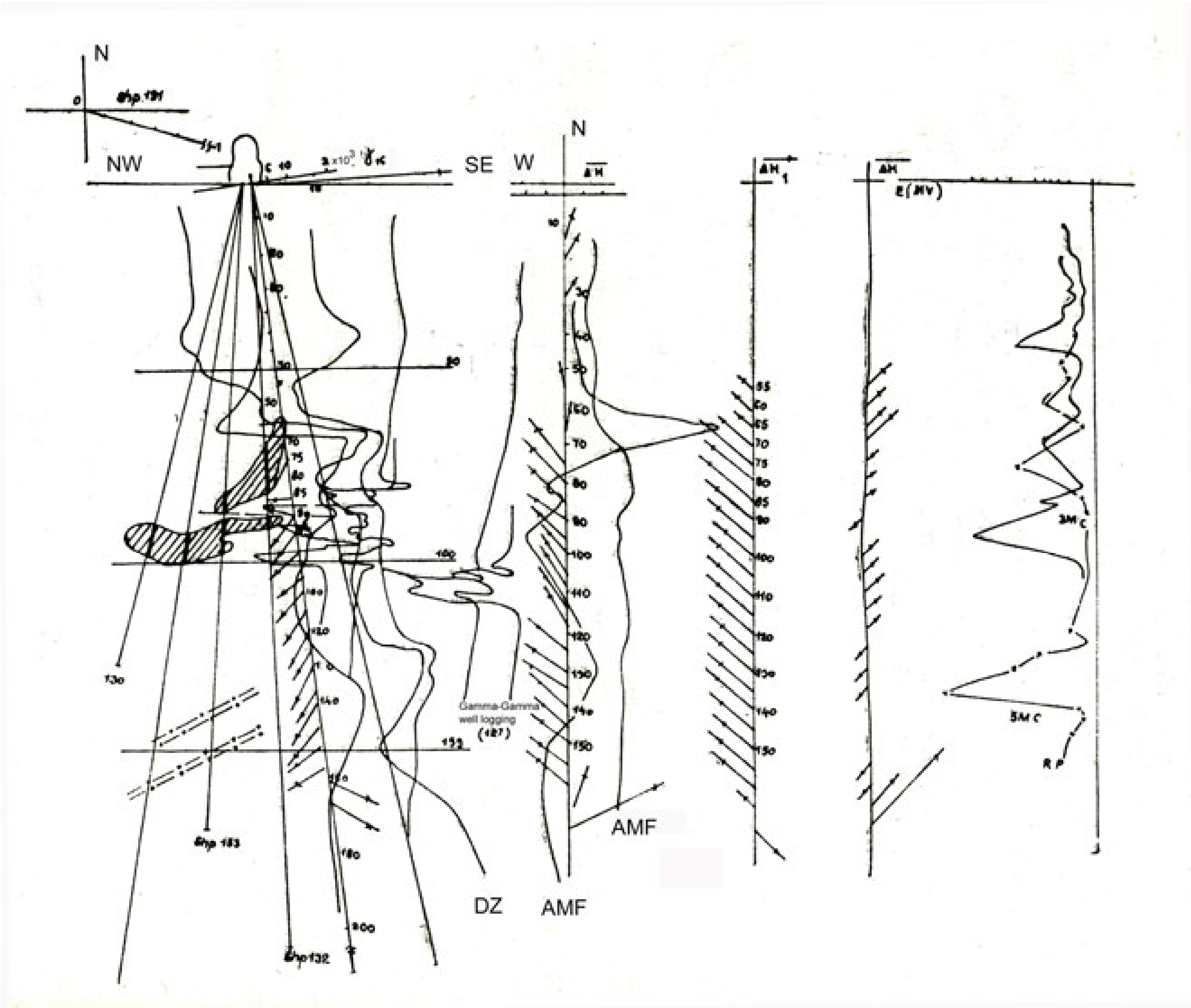

Fig. 4.26. Geological-geophysical section in L-L 5 underground magnetic survey line, Shkalla deposits, Bulqiza ultrabasic massif. (Langora Ll. Et al. 1989)

According to the geological-geophysical interpretation of the data in the L-L 5, and L-L 6 lines result following conclusions:

- Chromite ore body must located about 30-40 m from line L-L 6.
- Northern prolongation of the ore body is about for 40 m.
- Other ore body causes second anomaly.

Projected boreholes have discovered ore bodies.

Fig. 4-27 shows the undeground magnetic surveys in boreholes at Bulqiza deposit. The observed magnetic field in the borehole Sh. 4 represents an anomalous field above and underneath levels. Borehole Sh.3 has intersected the ore body. The interpretation of the plots of

the three component magnetic component Z and total magnetic component T showed that the ore body intersected by the bore hole Sh.2 in the forms of flexure, is connected with the ore body intersected by the bore hole Sh.3.

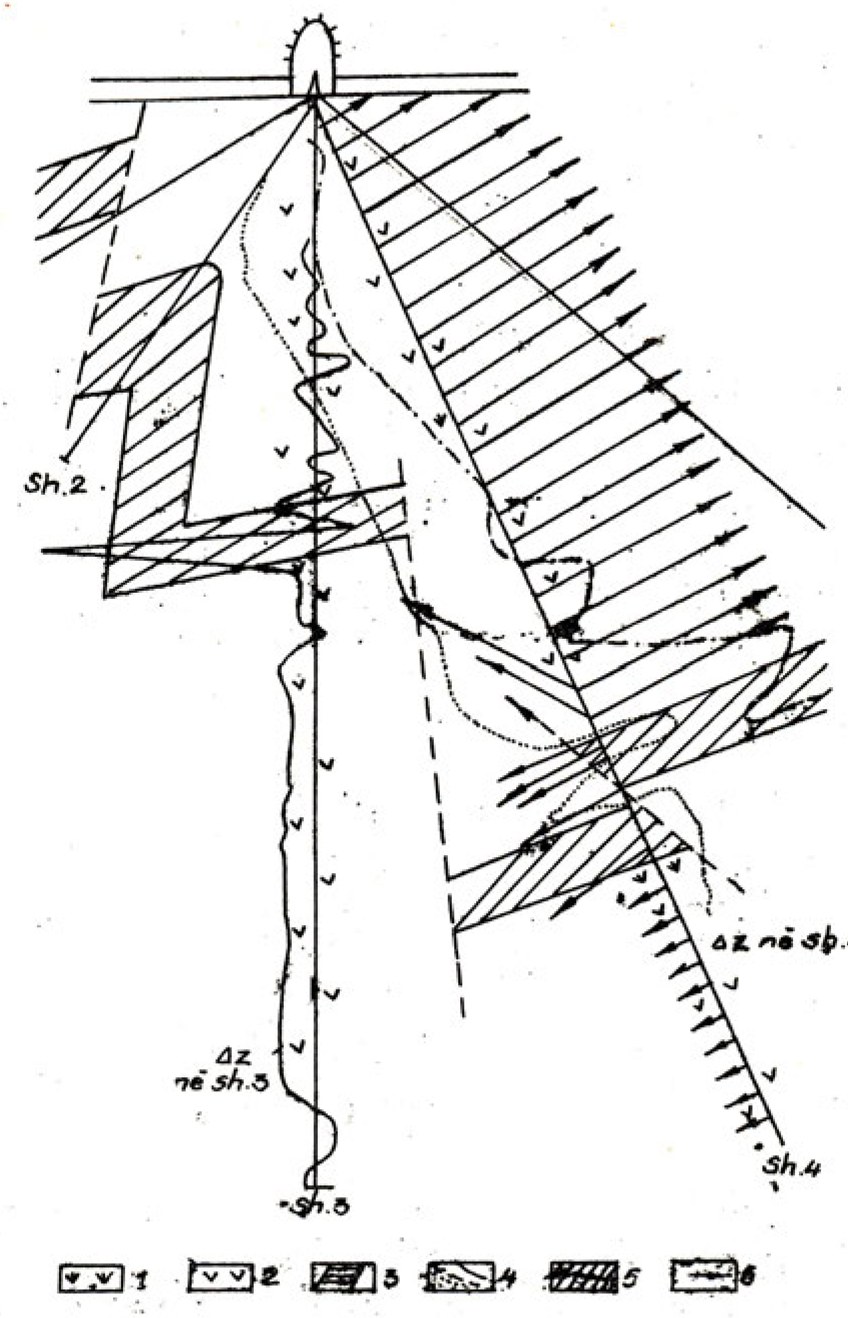

Fig. 4.27.Geomagnetic section according to three component borehole magnetic surveys in Bulqiza chrome deposit (Gjevreku Dh. 1984).
1- Dunite; 2- Hartzbourgite; 3- Ore body; 4- Vertical magnetic component (ΔZ) plot; 5- Total vector of the magnetic field intensity (ΔT).

In borehole S-17, which did not interest any orebody, an anomalous sector of the total magnetic field vector T at a depth of 190-330 m was observed (fig. 4-28). This anomaly was interpreted as being caused by a magnetic chromite ore body between the boreholes S-17 and S-16. The shallow boreholes S-1, S-2, S-3 and S-4 drilled at the end of gallery G-5 intersected the predicted orebody.

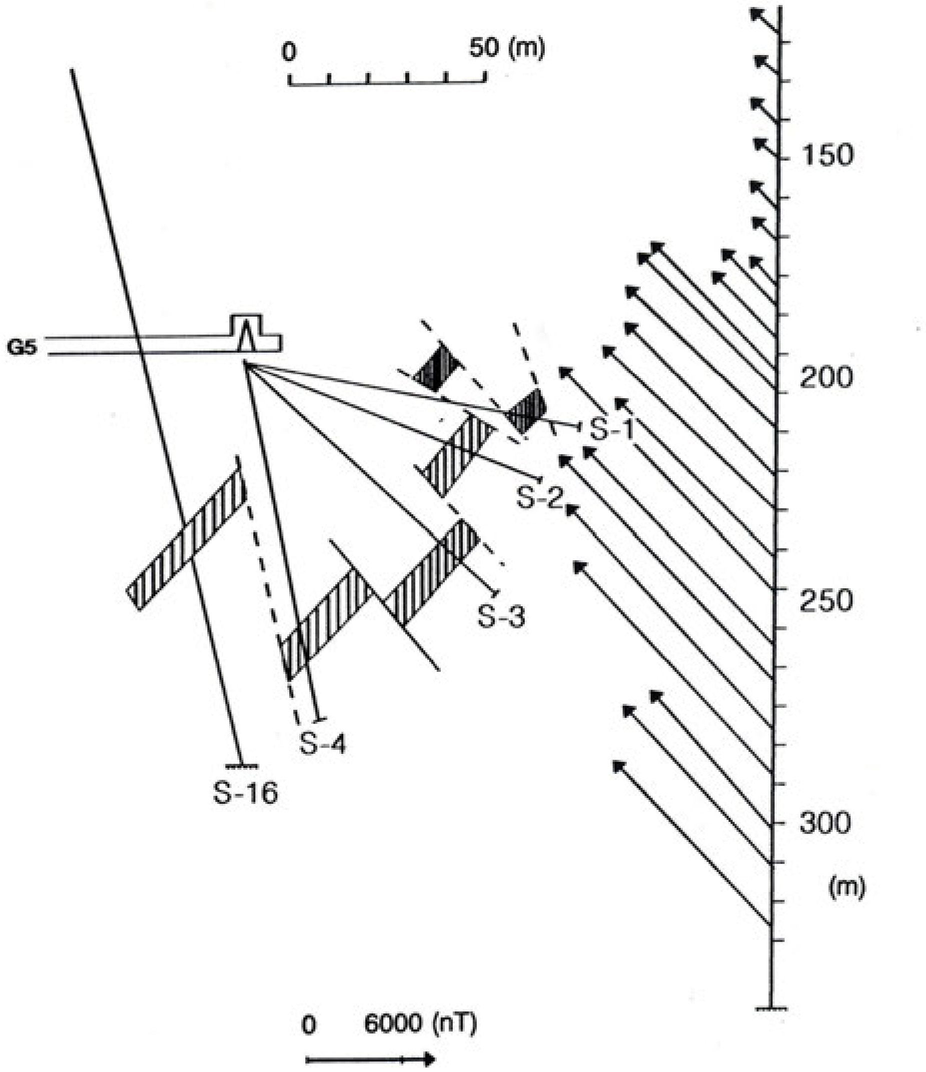

Fig. 4-28. Anomaly of total magnetic field intensity (ΔT), according to the three-components borehole magnetic field surveys for underground exploration of chromite ore (Gjevreku Dh., 1984, Lubonja L. et al. 1995).

The outputs of the radiowave floodlighting and radio wave profiling give good results when the chrome ore is magnetic and has dense up

to massive structure (fig. 4.29) The absorption coefficient values of electromagnetic waves of frequency 1 - 10 Hz for this area is b = (0.02-0.04) Neper/m, which is greater than for ultrabasic rocks (b = 0.0012-0.0015 Neper/m).

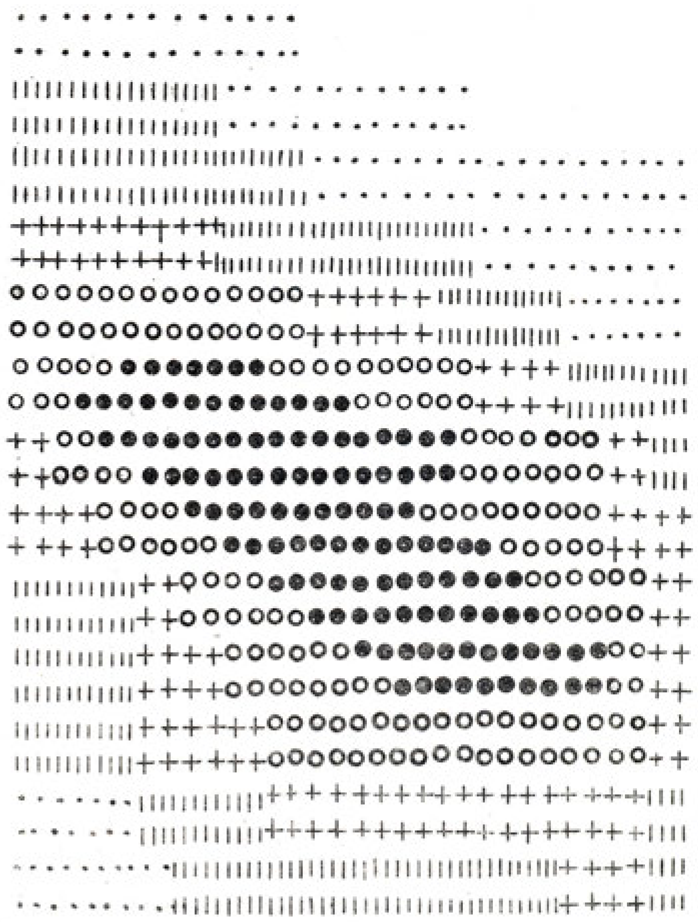

Fig. 4-29. The hologram of radio wave floodlighting borehole to borehole in Shkalla deposit (Mat district) (Gjevreku Dh. 1986).

IP methods can be used for the search of polarised ore bodies around boreholes by using the pole-dipole array N5M5A,B→∞ and N10M100A,B→∞, which can investigate a zone of a radius 7m and 60m, respectively.

The results of underground survey are not affected either by complicated topography, or by alternated rock inclusion nearly to surface. Mine works, metallic equipment and geological heterogeneity have an effect on these results. To avoid these influences, underground surveying is carried out by a special methodology and prior to the interpretation; the results are subjected to different mathematical processing.

b) Well logging

The geophysical methods have been used for geological documentation of the borehole trunk, ore bodies, tectonics faults and rock inclusions of different serpentinization degrees. Ore body thickness, deep layout, Cr_2O_3 content and the ratios Cr_2O_3/FeO, Cr/Al have been determined at a rather high accuracy.

The density is the more stable physical property, which in most cases is used for the selection of ore bodies from the surrounding media. The main method used for documentation of the borehole is the density and selective gamma-gamma logging (fig. 4.30.).

In the borehole log of the diffused gamma radiation (I_{gg}) the ore bodies can be outlined by radiation minimum, because they have higher density values than the surrounding rocks.

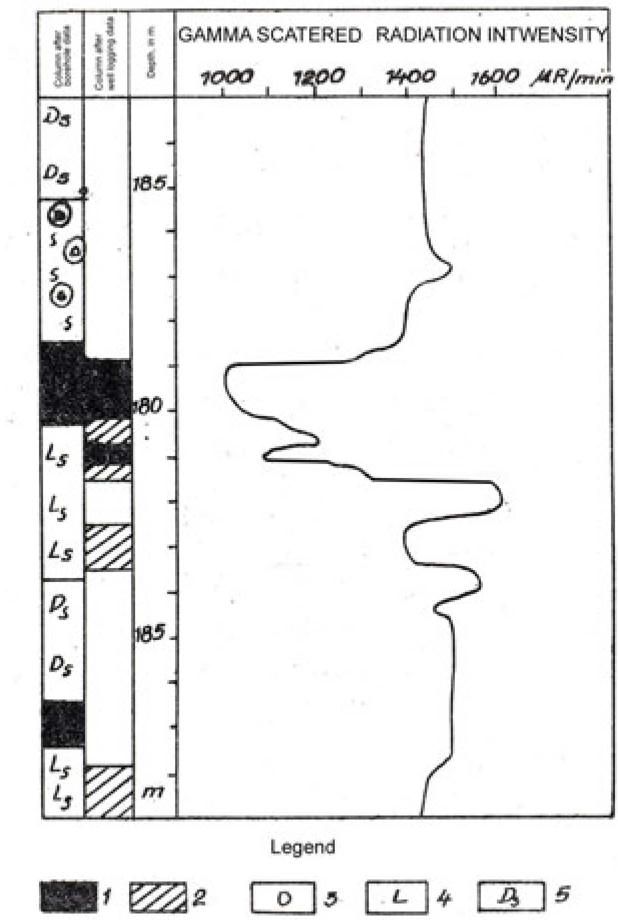

Fig. 4.30. Diffused gamma-gamma radiation log (Iγγ) in Luçiane deposit, Bulqiza massif (after Nakuçi I. well logging).
1- Massive ore body; 2- Ore body with disseminated structure; 3- Dunites; 4- Hartzburgites; 5. Serpentinized dunites.

From this figure can be seen that a detailed description of the borehole geological section and more accurate evaluation, together with partial drill logs, can be made according to well logging data interpretation.

Minimum points have been also observed in fresh, non-serpentinized, rocks individualizations, situated between serpentinized rocks. For discriminating these individualisations, a selective gamma-gamma-ray logging has been used. The intensity of smoothed component of scattered gamma rays, which is determined by heavy element content (as chrome) in the borehole section, is recorded by this logging.

Data on density gamma-ray logging can be used for the assessment of Cr_2O_3 content in the ores, for the computation of the ratios Cr_2O_3/FeO and Cr/Al, because it exist a correlation between the ore density and the Cr_2O_3 content, and between Cr_2O_3 and FeO and Al.

Magnetic and polarisable ore bodies are very well distinguished through magnetic and IP well logging. Serpentinized rock inclusions with secondary magnetite situated between fresh rocks give claire anomalies. These last ones can be used as geophysical indicators to distinguish tectonic sequences from cumulate ones, etc.

Chrome ore bodies can also be discriminated from ultramafic rocks by other parameters such as the effective atomic number 19, cross-section capture 0.054 cm^{-1}, which are greater for hartzburgite and dunite (effective atomic number 12.5 and cross-section 0.0015 cm^{-1}), and characteristic gamma ray spectrum (for high energetic levels 8.5 and 8.9 MeV). Based on these characteristics different kinds of logs, such as the neutron-gamma spectrometric, neutron-neutron, thermal and overthermal neutron logging can successfully be used for geophysical documentation. Ore bodies can be distinguished by higher logging values than those of the surrounding rocks.

As it was mentioned above, it can be seen that, for the geophysical documentation of the borehole in chrome deposit, the basic method to be used should be the radiation logging (density, gamma-gamma, selective gamma-gamma, aluminium neutron-activation, neutron-neutron, thermal neutron and overthermal neutron logging). The magnetic, the IP and conventional resistivity logging can be used as additional methods.

4.3. Geophysical applications for geological mapping

Geophysical methods contributing to geological structural mapping purposes, aimed at successfully solving some regional and local problems. The structure of ultramaphic rocks massifs and their relationship with the surrounding media have been studied. Serpentinized and fresh rocks, tectonic and cumulate sequences have been discriminated by their serpentinization degree. Tectonic faults and deep elements of primary structures such as flow and banded structures, S, L and Q system of primary fissures, the individualisation of fresh and serpentinized rocks were mapped in the ore fields. The conditions of rock formation and their changes in space and time during the geological history have been studied for the mapped regions. During the exploration-developing stage have been studied, at a more detailed scale, the factors controlling the mineralization.

For accomplishing geological-structural mapping tasks, have been used different kinds of geophysical methods such as gravitational, magnetic, micromagnetic mappings; magneto-telluric and electromagnetic soundings; low and high frequency seismic prospecting for big and shallow depths studies, respectively. These works have been accompanied by petrophysical studies

Valuable information about the geology of Bulqiza ultramaphic massif and about other massifs has been received by gravitational mapping at the scale 1:25000 (Kosho P.). In the figure 4.31 is shown a geological geophysical line in Klos-Bulqize-Shpuze (Frasheri A. et al. 1990).

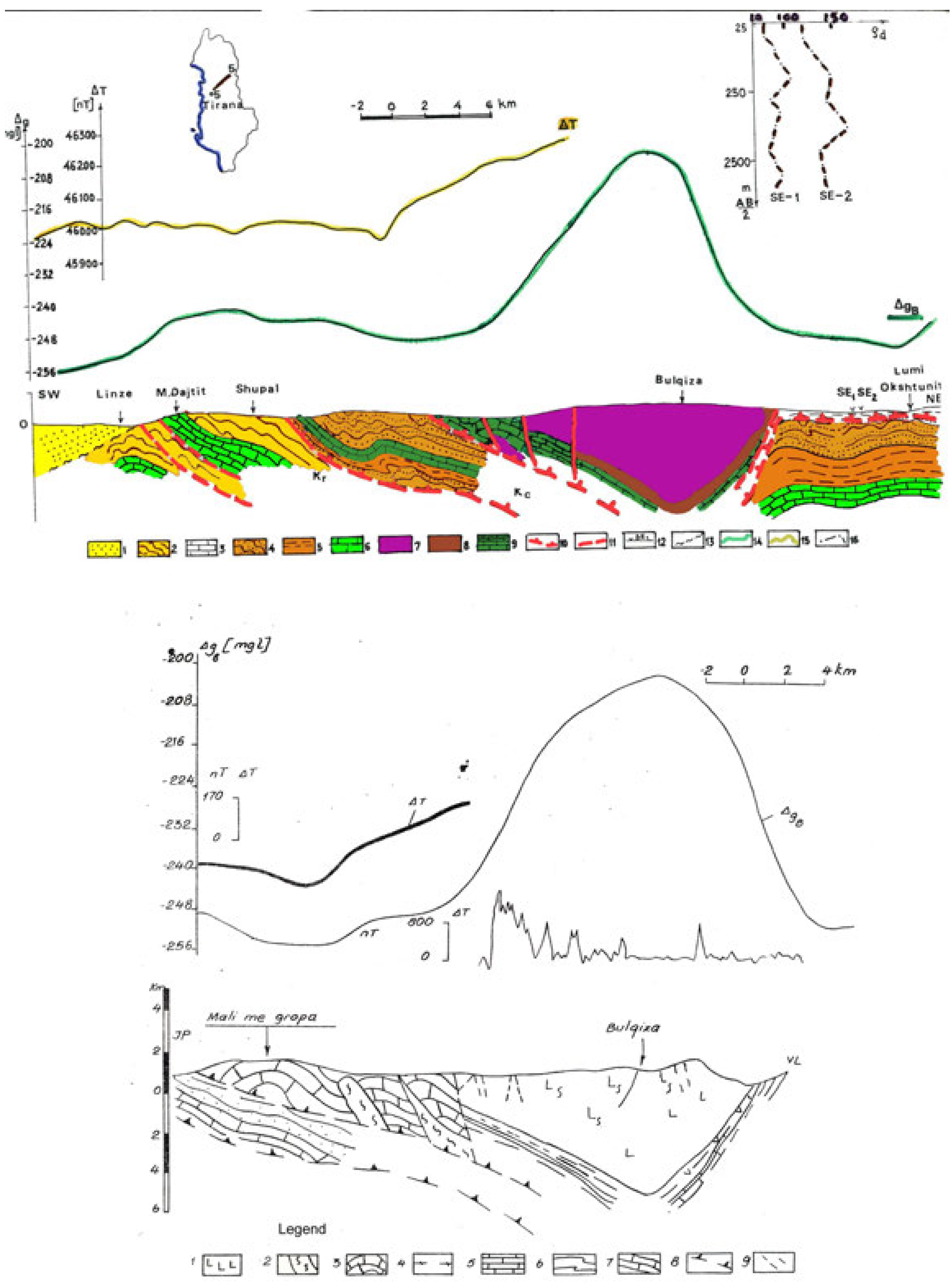

Fig. 4-31. Geological-geophysical line in Klos-Bulqize-Shpuze (Frasheri A. et al. 1990).

1 - Hartzburgites, 2 - Serpentinites, 3 - Triassic limestones, 4 - Volcano-sedimentary series, 5 - Jurassic limestones, 6 - Cr^2 - Pg^3 flysch, 7 - Pg^2 limestones, 8. Cover tectonics, 9 - Disjunctive tectonics.

According to the interpretation of the Bouguer anomaly, the massif has an inverted conic shape. Its thickness is smaller at the edges and increases towards the centre (up to 5.5 km). Based on the distribution of the magnetic field, the serpentinized sector of the ultramaphic rocks and the flanks where re massif is covered by the Neogene molasses sediments (especially the western flanks) have been mapped. The intensity of the magnetic field in these sectors is high due to the content of secondary magnetite. In plane, the anomalies have a mosaic picture, due to heterogeneous distribution of secondary magnetite. In these zones are also found some local minimums.

These characteristics can be used as features for the discrimination of cumulate sequences. Magnetic anomalies of cumulate sequence have high amplitude and high frequency. Anomalies on dunite-hartzburgite tectonic sequences are characterised by smaller amplitudes and lower frequencies, meanwhile the intensity of the magnetic field is smaller than for hartzburgite-tectonite sequences. The correlation of different geophysical parameters, determines different perspective levels of ultramaphic cross sections, which help the search for mineralization.

Micro magnetic survey has given good results in determining the primary textural elements in zones covered by 2-3 m thick soft sediments and in zones where these elements cannot be seen. This is possible because the axis of the magnetic micro anomalies have two directions, one parallel with the fissures systems L, S and flow and banded textures, and the second one which coincides with Q fissure system.

The picture of the distribution of magnetic micro anomalies can be explained by the layout of the secondary magnetite mainly according to flow, banded textures and the fissures system L,S and C (fig. 4.32) and to the direction of the vector of thermoremanent magnetization, which coincide with the direction of primary structural elements.

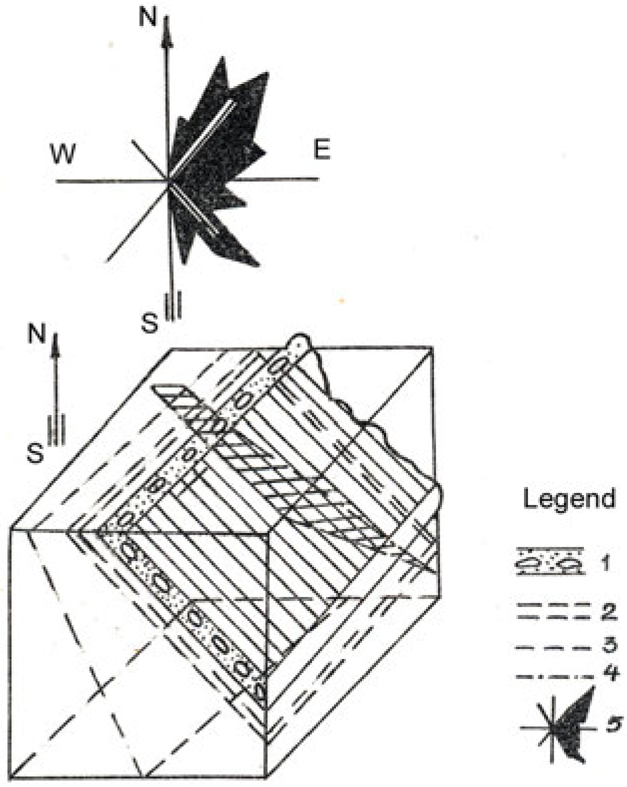

Fig. 4.32. Primary structural elements and the direction of the axis of magnetic micro anomalies. (Frasheri et al. 1969).
1 - Banded texture; 2 - Primary fissure system L, 3 - Primary fissure system S, 4 - Primary fissure system Q, 5 - Rose diagram and vectors of the direction of the magnetic micro anomalies axis.

From the performed magnetic micro surveys, it seems that the axes of magnetic micro anomalies are the same for the dunitic rocks and the hartzburgite. That means that different kinds of rocks of tectonite-hartzburgite-dunite sequence have had the same development during the geological history. Dunites and hartzburgites can only be distinguished by unequal degrees of the serpentinization. The difficulty in distinguishing them is explained by the fact that these rock have physical properties which vary in a wide range and sometimes overlap each other.

Serpentinites, generally, have high contents of secondary magnetite and are magnetic. Therefore the magnetic surveying can be used to study the weathering layer for the search of nickel-silicates.

Geological geophysical studies of chrome ore fields have been carried out simultaneously with regional geological-geophysical mappings and petrophysical studies. These last ones have been used as a

supplementary information source about the rock formation conditions, their composition and their changes in space and time. Such data are given in studies about the rock magnetism and its nature.

In the Tropoja ultramaphic massif has been observed an increase of the rock's density values, from the eastern part to the western one (particularly after Kami). That indicates that the rocks in the western part of this massif are less serpentinized than the ones in the eastern part. In the same direction can be distinguished the dunites from the hartzburgites of tectonic sequence. The hartzburgites have higher density values than the dunites. In the western part of the massif, is observed an increase of the content of pyroxenites inside hartzburgites and the degree serpentinization for these two kinds of rocks is different.

4.4 <u>Some important conclusions and recommendations</u>

Based on the results of geophysical investigations for the search of chromite in Albania and in other countries of the world, some conclusions can be made:

Geophysical anomalies are fixed on ore bodies and on rock inclusions. That means, not every anomaly may indicate about the presence of an ore body.
On chrome ores there are not always geophysical anomalies. That means that the lack of anomalies does not necessarily indicate about the absence of ore bodies.

The wide variation of the ore's physical properties and those of the surrounding rocks can explain these, by the small differences between these physical properties, by the shape and the small dimensions of ore bodies compared with their layout depth. Therefore, a geophysical anomaly can indicate only about the possibility of the existence of an ore body.

This anomalous situation is presented in the table 4.1.

The characteristics of the anomalous geophysical picture, in the regions where chrome ore deposits are searched.

Table 4.1

Chromite ore and surrounding rocks	Gravity anomalies	Magnetic anomalies	Induced Polarization anomalies
Massive chromites, magnetic and polarizable	+	+	+
Massive chromites, magnetic, unpolarizable	+	+	-
Disseminates chromites, magnetic and polarizable	-	+	+
Disseminates chromites, nonmagnetic, polarizable	-	-	+
Fresh ultramaphic rocks Individualization	+	-	-
Serpentinized ultramaphic rocks individualization	-	+	+
Serpentinites intersected by gabbro-pegmatite dykes of cumulate sequence	+	+	+
Gabbro pegmatite dykes or frech pyroxenites	+	-	-

In figs. 4-33 and 4-34 are presented a theoretical dependences of gravity anomalies (Bourguer reduction and vertical gradients) by mass/radius and depth of the ore body centres for a model in the sphere shape or horizontal cylinder, to have the possibilities to observed the anomalies, respectively with amplitudes 0,2 and 0,4 mGal, and 20 Oetvesh.

According to these calculations, by gravity surveys is possible to discover chromite bodies in different depth, from tens to hundred meters, if will exist necessary mass of the ore body. For example, the ore body with radius 14,5 m and mass 50.000 tons, is possible to explorer up to 23,5 m depth of location, because the Bouguer anomaly will has an amplitude about 0,2 mGal. The mass about 3.500.000 tons can be explored at 200 m depth of location, by survey such anomaly, 0,2 mGal.

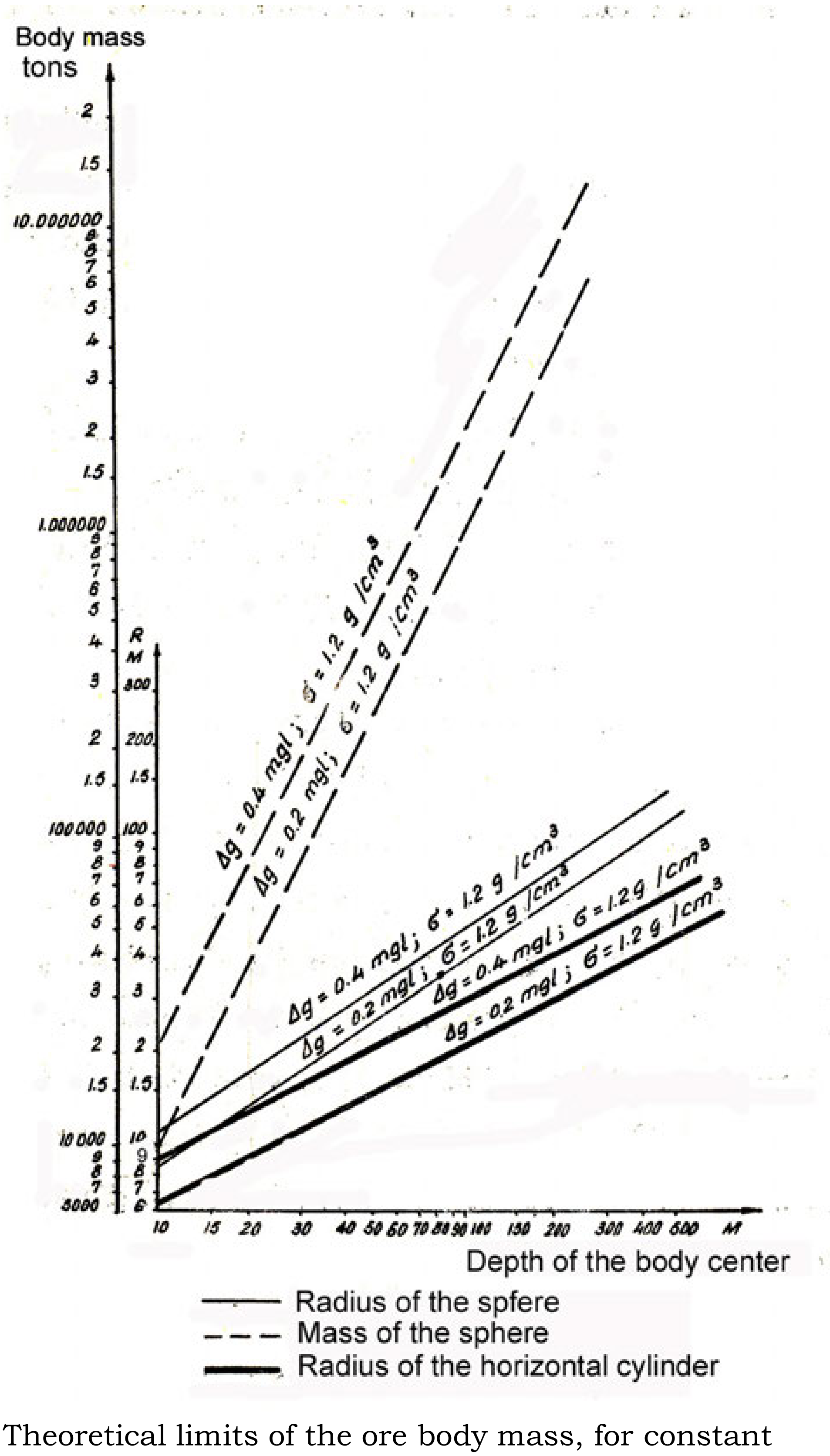

Fig. 4- 33. Theoretical limits of the ore body mass, for constant Depth of location of ore body, which will created an Bouguer anomaly of an amplitude Δg- 0,2 and 0,4 mGal. (Frasheri A. 1968, 1974)

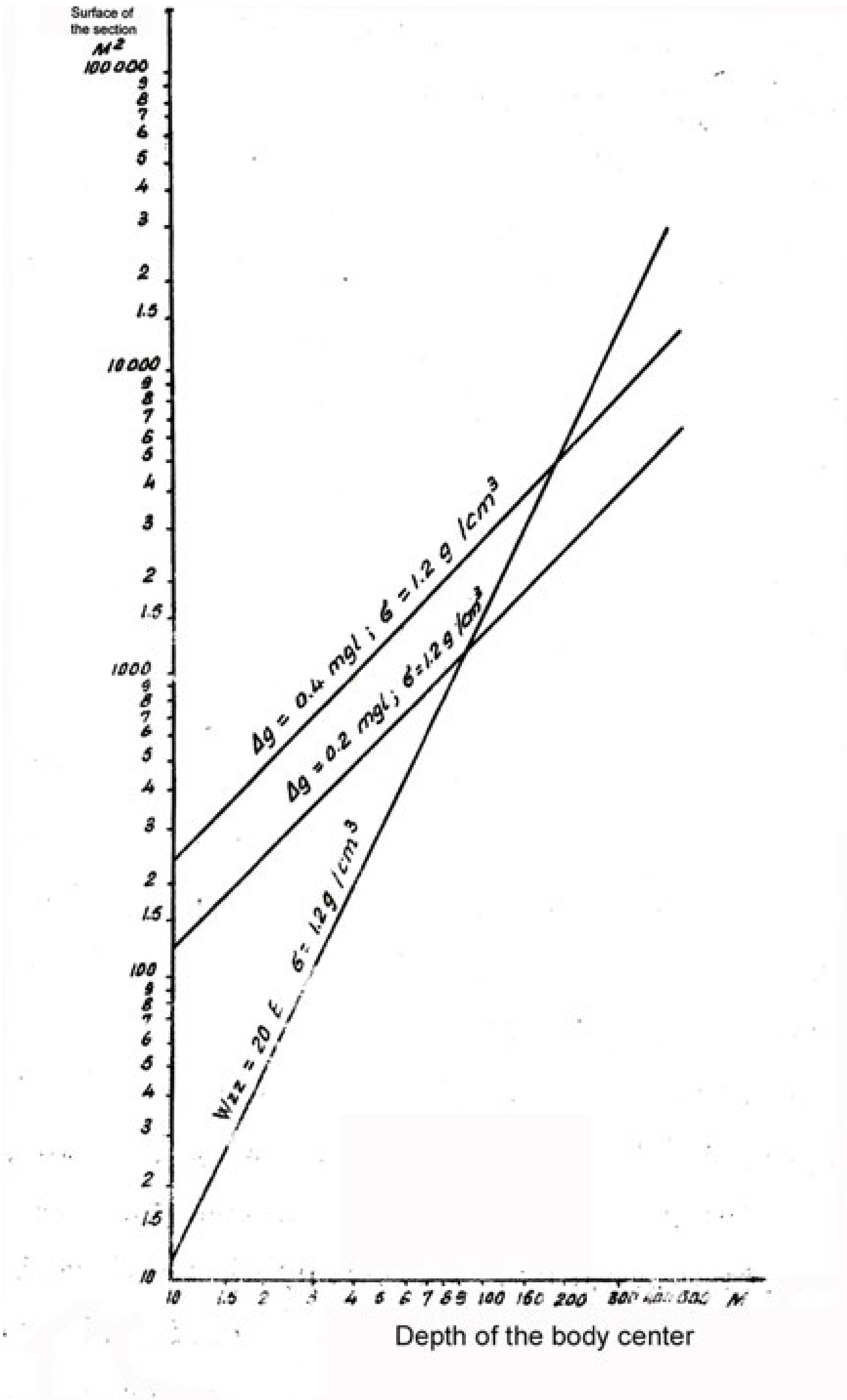

Fig. 4-34. Theoretical limits of the horizontal cylindrical ore body section surface, for constant depth of location of ore body, which will created an Bouguer anomaly of an amplitude Δg- 0,2 and 0,4 mGal and Wzz= 20 Oetvesh. (Frasheri A. 1968, 1974)

These limitations create the need for the implementation of some measures to increase the effectiveness of geophysical search:

Direct search for chrome ore bodies should be carried out simultaneously with the geophysical-structural mappings and petrophysical studies in order to know the factors controlling the mineralisation.

Surface and underground geophysical surveys (gravity, magnetic, geoelectrical ones) should be carried out in complexity. In the interpretation of the results should be considered all other existing geological information. This will make possible the determination of the nature of an anomaly, so that the ones caused by ore bodies can be selected. Better combination of surface with underground surveys leads to the increase of the search depth of the geophysical methods.

Geophysical works can achieve better results when perspective zones are the exploration objects. The work should start from well-known ore bodies and not from small sectors.

Geophysical studies should be carried out in the framework of complex geological studies. Only in this way can better be studied the geology of the ultramaphic massifs, the premises for the search of ore deposits and ore bodies underneath the surface of the Earth.

Since the number of shallow or near- surface ore deposits is decreasing, the implementation of geological methods, at present, is a necessity in order to increase the search depth for chrome deposits.

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GENERALIZED GEOPHYSICAL OVERVIEW ON SHKODËR-PEJË DEEP TRANSVERSAL FRACTURE

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Abstract

The article presents an attempt to generalize the complex of geophysical data: Gravity, Magnetic, Paleomagnetic, Geothermal, Seismological and Remote Sensing of Cukali tectonic subzone, where it crosses the deep transversal fracture Shkodër – Pejë, as well as marine seismic data, and hydrological observations on the shelf of the Southern Adriatic Basin. Analyses of the results of these studies are based on regional geological setting data.

Regional geological-tectonic setting of Shkodër-Pejë sector of Mediterranean Alpine Folded Belt, presents the existence of this important disjunctive deep tectonics element. The geological surveys and detailed mapping at the scale 1:25.000 up to regional ones at the scale 1:200.000, does not have traced at the Earth's surface the outcrop of this thrust. Consequently, have brought about the different concepts on it: "scharung" (1901), "deviation" (1920—1930), "an accident" (1960), "transform transversal fault" (1970-2012), "transverse fault" (1990-2012), "deep transversal fracture" (2012), and to silence about its existence, even to denial of its presence. These changes in the course of a century, not just in terms of use, were related to different geological schools over the geological setting of the Albanides. This transformation of concepts, unfortunately even in our days in some studies, related to the fact that the geological hypothesis or theories about the geological-tectonic setting of the region, were formed solely on the basis of surface geological surveys, which undertake to presented geological setting to the Moho Discontinuity without geophysical data, as necessary to known the depth.

During the last two decades, the Shkodër-Pejë region was involved in geophysical surveys polygons. Gravity Bouguer Anomaly Map, Magnetic Anomaly Map, Paleomagnetic Studies, Heat Flow Density Map, analyze of the satellite imagery, have provided important information about tectonic setting in the depth of the region. This information, interpreted in complex with the existing geological-tectonic data has cast light on the depth of the area, where it crosses the transverse Shkodër-Pejë. They argued that it represent a deep transverse vertical fracture, which affects the Moho Discontinuity. Its amplitude at those levels is about 4 km. It decreases toward the Earth's surface, until extinguished in some segments. This fracture represent a wide belt, was also interrupted by the deep regional or lowest order longitudinal thrusts.

Key Words: Mediterranean Alpine Folded Belt, Shkodër - Pejë transversal, geophysical anomalies, deep fracture.

1. Introduction as a historic review

Hellenides-Albanides-Dinarides, branch of the Mediterranean Alpine Folded Belt, are interrupted by a deep transversal tectonic fracture in the Shkodër-Pejë segments. This fracture is correlated with contact between Eurasian and African Plates in Drini Bay in Adriatic Sea (Fig. 1-a). It has been Svijich Jovan who described this fracture, calling "scharung", for the first time in his book "Die Dinarics Albanische scharung-sitzba", 1901 [Cvijich, 1901]. Later, during the first half of last century, this "scharung" is called as "deviation" by many Austrian, French, German, Italian, and Serbian researches, as Kosmat F. (1924), Koberh L. (1929), Nopca F. (1929), Bourcart J. (1919, 1925), Novack E. (1929), Zuber S. (1940) et al., have mentioned also Shkodër-Pejë zone, which differs clearly in tectonic and geological maps of Europe (Fig. 1-b, 1-c, 1-d).

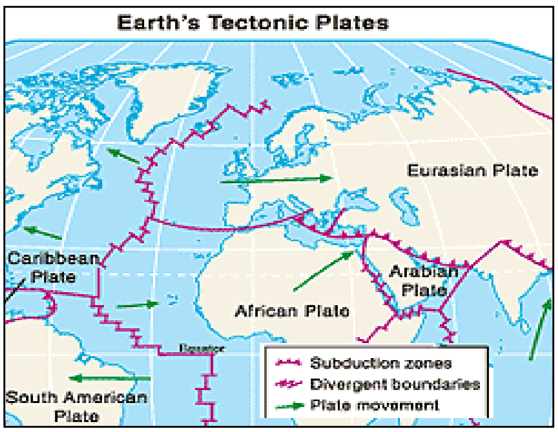


Fig. 1. Shkodër-Pejë deep transversal fracture belt according to the geophysical data:
Fig. 1-a: Earth's Tectonic Plates Map;
Fig. 1-b: Western Balkans Tectonic Maps [International Tectonic Map of Europe, at scale 1:5.000.000].

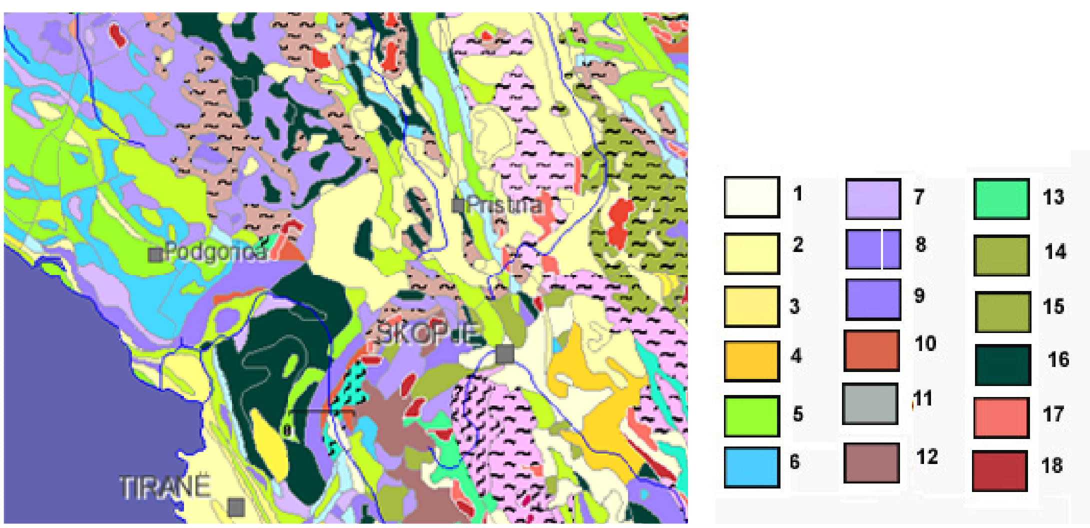


Fig. 1- c: Regional Geological settings of central part of western Balkan Peninsula [Geological Map of Europe, http://www.bgr.de/igme5000/igme_frame.php].
1- Quaternary; 2- Neogene; 3- Oligocene; 4- Paleocene-Eocene; 5- Cretaceous; 6- Jurassic; 7 - Alpine, 8 - Triassic; 9 - Mesozoic; 10 - Permian; 11- Carboniferous- Permian; 12- Devonian; 13- Silurian; 14- Cambrian; 15- Palaeozoic; 16- Ophiolite complex; 17 - Palaeozoic plutonite; 18- Mesozoic plutonite.

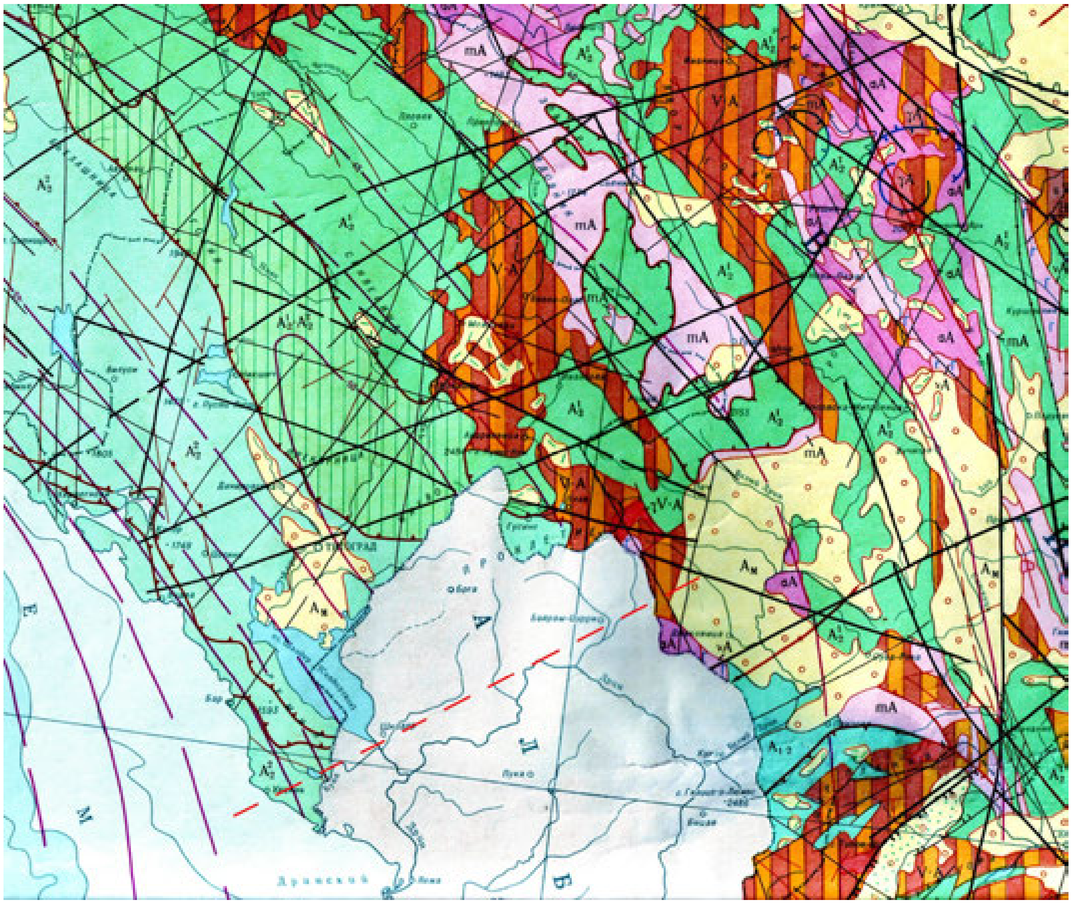


Fig. 1.d. Cosmotectonic Map of European Countries, SEV and SFRJ members, at the scale 1: 1.000.000 (Union Aerogeologia- Geological production for regional studies of geological setting of country territory, 1987)

__________ Lineaments interpreted not so unique (hidden fractures, planetary fissures, flexures)

_ _ _ _ _ _ Shkodër-Pejë deep fracture according to the geophysical data.

In the second half of the 20th century, the French geologist Aubouin J. and Albanian geologist Ndoja I. Gj. have called the Shkodër-Pejë fracture as “accident“ [Aubouin J. & Ndoja I.Gj. 1964]. Later, Aubouin J. has considered “ancient transform fault” the Shkodër-Pejë transversal, and as an “element inherits of the Tethyan Ocean paleogeography” [Aubouin J. et al. 1970]. Like a “Faille transversale Scutari-Pec” was presented by Çollaku A. & Cadet J.P. (1991).

After these, for almost several decades in Albanian geological studies, this fracture had not been mentioned, because the Albanides geological setting and its geologic history (palaeogeographic and tectonic) had been based on geosyncline’s theory [Geology of Albania, 1970].

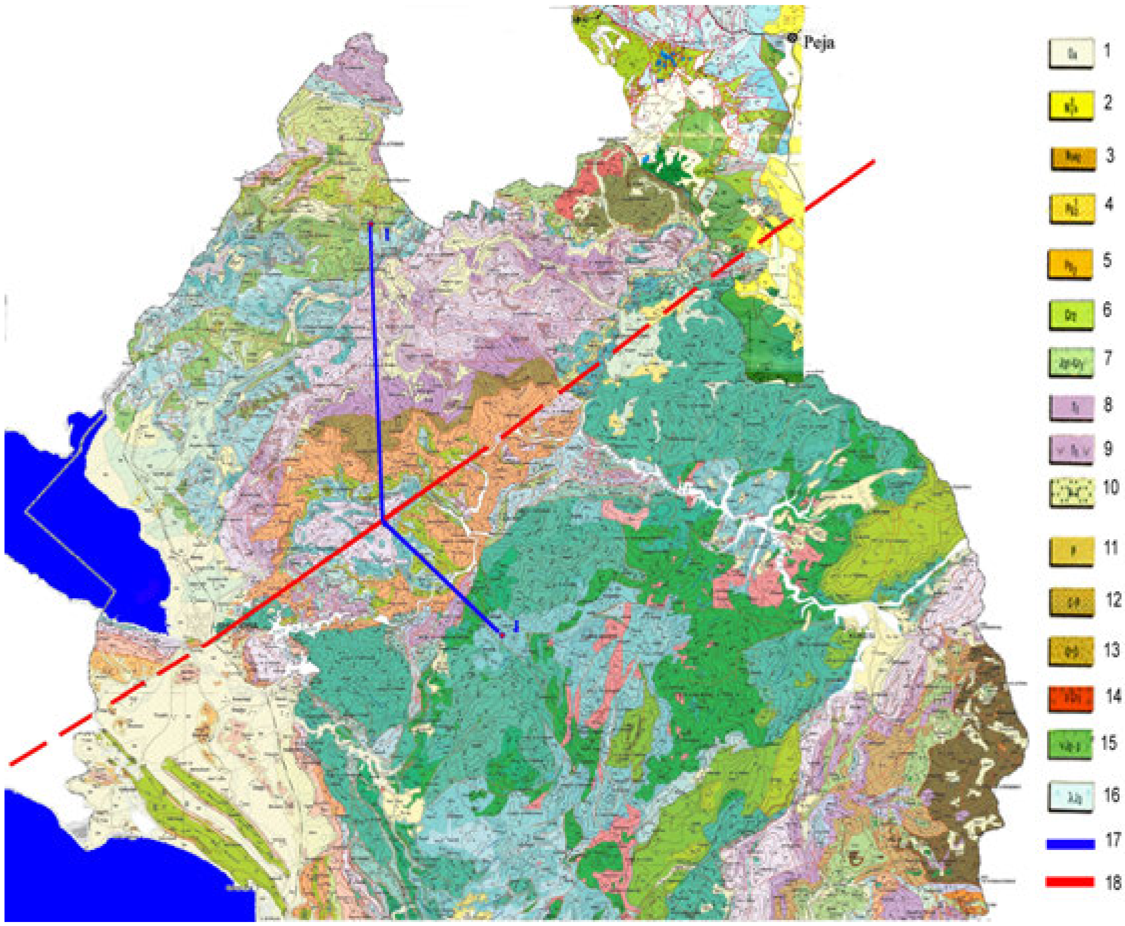


Fig. 1-d: Geological Map of Northern region of Albania, at scale 1:200.000, (Xhomo A. et al. 2002), and neigbor area from the Geological Map of Kosova.
1-Quaternary; 2- Neogene, molasse, 3- Lower Neogene-marlstone and flyschoid formation; 4- Oligocene, flysch formation; 5- Eocene-Paleocene, limestone; 6-Cretaceous- carbonate formation; 7- Jurassic- carbonate formation, melange; 8- Triassic- carbonate – terrigene formations; 9- Lower Triassic- volcanite formation; 10- Permian-Triassic- evaporate formation, gypsum; 11- Permian- limestone, sandstone, conglomerate, schist; 12- Carboniferous-Permian- sandstone, conglomerate, schist; 13- Ordovician-Devonian- limestone, schist; 14- Plagiogranite, granodiorite; 15- Ophiolite complex; 16- Jurassic- splitite, keratophyre – diabase 17- Gephysical inversion line; 18- Shkodër-Pejë deep tranversal fracture according to the gravity Bouguer anomaly inversion.

Later, seismological studies argued the presence of an active fault zone according to the well known Shkodër-Pejë direction [Aliaj Sh. 1999, Muço B. et al. 2001, and Sulstarova E. et al. 1972]. The authors of the Geologic Map of Albania [Geology of Albania, 1970] and latter Papa A., Xhomo A., et al. have analyzed Shkodër-Pejë transversal and its role in Albanides (Papa A. et al. 1985, 1991).

They mentioned it as a transversal zone, which represents an area where there are rapid paleogeographic transitions, with the presence of a talus, connecting the Albanian Alps Ridge with the Krasta-Cukali Groove. They wrote, also, that this area marks the southern paleogeographic closure of the Albanian Alps Ridge, constituting the paleotectonic etape, the natural boundary between the northern and southern Albanides. Melo V. wrote "…in the Southern side of the thrust, which some described as transform fault, lies Mirdita tectonic zone of Albanides [Melo V. 1986]. Shkodër-Pejë thrust as a transform-transversal fault is considered also by many authors, mainly by the autoctonists, which accepted the formation of ophiolitic belt as a result of the Mirdita Ocean opening [Kodra A. et al. 1994, Melo V. et al. 1991]. Shkodër-Pejë "scharung" is considered a real tectonic regional element, because the area of the Albanian Alps, with compelling scientific basis, so far not yet found in southern Albanides, according to the Peza L. et al. (1971). According to Aliaj Sh. "…the Shkodër-Pejë transverse fault dividing Dinarides from the Hellenides" [Aliaj Sh., 1999, 2006]. Some geologists did not mention this fracture among those who analyze their books became [Vranaj A. et. al. 1997]. Shehu V. has written "so called Shkodër-Pejë transversal" and denied its existence, accepted that this tectonic line represents simply the border of the northwest front of the Mirdita's zone [Shehu V., 1967].

During the last quarter century, the geophysical studies, and remote sensing that were carried out have a cast light on the Shkodër-Pejë fracture, giving new evidences on its structure. In satellite images, Chorowicz J. has observed some tectonic lineaments along the Shkodër-Pejë transversal zone [Chorowicz J. et al. 1981]. In the paper, related to the study region, are presented and analyzed the offshore geophysical exploration results at Montenegro Adriatic shelf and littoral [Dragasević T., 1983], and remote sensing surveys (Frashëri N. 2012).

Is important to show that the existence of Shkodër – Pejë thrust and its position cannot being observed and mapped during geological field surveys, even at the 1:25.000 scale [Qirinxhi A., et al. 1983]. Qirinxhi A. confirmed that in the field they were not capable to distinguish the tectonic borders between the Paleozoic (of Albanian Alps tectonic zone) and Paleogenic black schists (of Cukali tectonic zone). Because the tectonic border between them does not represent the Scutari-Pec fracture, about this fracture they had not discussed. Later, during the Symposium "Thrust Tectonics in Albania", they sustained that Shkodër-Pejë fracture does not exist on the surface but, perhaps, exist in the depth [Qirinxhi A. et al. 1991].

The above interpretations regarding the Shkodër-Pejë fracture also have resulted in alternative of the geological opinion concerning its position. Some authors, who admit the opening of the Mirdita Ocean and interpreted this transversal as oceanic transform fracture. After them, Shkodër-Pejë transform fault is represented by the north-western front of the ophiolitic belt [Xhomo A. et al. 2002]. After some other authors, this transversal is represented by the northern border of Cukali subzone as natural geological border between Alps Zone and Cukali ones [Papa A. et al. 1991].

2. Methodology of Study

Already avalaible are the results of integrated surveys and studies, which include Shkodër-Pejë fracture zone [Frashëri A. et al 2009].

Geologic-tectonic settings of Shkodër-Pejë region is included in the regional Geological Maps of Albania, by Nopça F. (1929), Novack E. (1929), and Zuber S. (1940), in the Geological Maps of Albania at the scale 1:200.000 (1967, 1983, 2002), and in the Tectonics Map at the scale 1:200.000 (1984), Neotectonics Maps of Albania, and seismicity studies [Sulstarova E. et al. 2011]. Detailled geological setting of the Kiraj-Ndreaj-Brashtë in Cukali zone was presented in the Geological Map at the scale 1:25.000 [Qirinxhi A. et al. 1983].

The seismicity of Albania was study by analyze of the historical and instrumental data, and the distribution in time and space of the seismic activity in Albania and surrounding areas. The study covers a period of about 2000 years. During the period about half a century have been compilated

the catalogues of Earthquakes in Albania up to 2005, and Atlas of the Isoseismic Maps for 198 earthquakes occurred in Albania and nearby during 1800-1990 [Sulstarova A., et al. 2011]. Present-day stress field in Albania was study based on the earthquakes focal mechanism solutions in the complex with structural analysis of the faults from Middle Pleistocene up to our time, and neotectonic analyze [Aliaj A. 1988, Sulstarova E.1986, Tagari Dh.1993, Muço B., 1994]. The seismic hazard estimation of Albanian territory, which presents a part of the seismological studies, is accompanied and with important geological information to investigated the Earth Crust structure of Albanides.

Have been compilated the Map of Gravity Bouguer Anomalies of Albania [Bushati S., 1988] and Map of Total Magnetic Vector (T) of Albania [Bushati S., 1998] at the scales 1:200.000. For the Shkodër - Pejë area have been observed also two detailled profiles (Fig. 1-b). Gravity and magnetic surveys were accompanied with density and magnetic properties of the rock detailled studies (Qirinxhi A. et al. 1983).

The dynamic evolution of the Albanides is recorded in the paleomagnetic data, collected from the paleomagnetic studies in Albania during 1991-1995: Frashëri A. and Bushati S., 1995; Kissel C. et al., 1992, 1994, 1995; and Mauritsch H.J., Scholge R., Bushati S., 1991, 1994; [Frashëri A. and Bushati S. 1995, Kissel C. et al, 1995, Mauritsch H.J., et al. 1995, Speranza F. 1995].

Geophysical investigation has provided some information related to the crystal basement of Albanides (Aliaj Sh. 2006; Frashëri A. et al. 1991, 2004, 2010; Bushati S. 1988, 1998; Koçiu S. 1989). In particular, was analyzed the propagation of the Earth Thermal Field. This analysis has been performed according the Heat Flow Density Map, based on the temperature records in boreholes at Ragami in Tropoja region, and Palaj-Karmë zone [Frashëri A. et al. 2004].

Remote sensing based on Landsat and Modis data was used to identify some regional geological features and analyse the ground temperatures.

The ofshore area of Drini Bay, at the south-western edge of Shkodër - Pejë fracture zone, is included in the contour of the polygone of offshore geothermal studies in South Adriatic Sea. Was observed marine currents, waves, water salinity and temperature at various depth, as well as Earth Heat Flow Density at the sea bottom (Frashëri A. et al. 2011, Geothermal Atlas of Europe, 1992).

3. Results and discussion

Complex methods used for studies also in northern Albania and in the Adriatic Sea have brough the new information of great value for the Albanides depth, and which throw light on the Shkodra - Peja fracture zone. Follow separately analyze for results from each used method, and in the end will be presented their generalization.

Geophysical investigation results show that crystal basement of Albanides has a blocks character (Fig. 2) (Bushati S., 1988, 1998, Koçiu S., 1989, Frashëri A. et al. 1991, 2010). Thickness of the location of these blocks is shallower in Mirdita Tectonic Zone. The crust construction and their dynamics are reflected in the geological setting of the Albanides tectonic zones, and their tectonic styles. Block structure controlled by a system of NW-SE longitudinal faults as well as transverse ones.

Local heat hearths put in evidence the transversal faults. Geothermal energy is related with a great heat flow through these fractures (Fig. 3) [Frashëri A. et al. 2004].

The Shkodër-Pejë deep fracture represents one of deep thrusts, which transversally divides Albanides in two parts (Fig. 3, 4). In northern part are including western-northern edge of Kruja tectonic zone, northern part of Cukali zone, Albanian Alps and Gashi zones, which follow by the Dinarides tectonic zones: Budva, High Karst, Dalmate, Durmitor, Serbian, and Golia zone. In the southern part of the Albanides, represented by Sazani, Ionian, southern part of Cukali zone, Krasta-Cukali, Mirdita and Korabi tectonic zones, which follows by the Hellenides. This deep fracture

generally considered a multi phase's transversal tectonic faults zone, with a north-eastern extension of about 30°. Consequently, Shkodër-Pejë deep fracture divides two big areas with different geological settings and developing geological history, but not only in the continent, also to the orogenic front in the Adriatic Shelf.

The Albanian orogenic thrust front is cut and displaced by the Othoni Island-Dhërmi, the north of Sazani Island, and the Gjiri i Drinit-Lezha strike-slip faults, which divide the orogen into separate segments showing diachronous development (Fig. 5) [Aliaj Sh., 2006]. The orogenic front, north of the Drini Bay-Lezha town strike-slip fault, in the Adriatic offshore, belongs to the Kruja Zone. The buried orogenic front, north-west-trending here, is expressed by the Kruja Zone thrusting over the Albanian Basin. The external margin of the fold and thrust belt in Albania was thrust on the Adria microplate, partly over the Apulian Platform and partly over the Albanian Basin [Aliaj Sh., 2006]. During the Tertiary phase, this strike-slip fault functioned as a right pushing, being shifted towardsthe south-western inner zones [Sulstarova E. et al. 2011]. Ophiolitic Belt of the Mirdita Tectonic Zone is displaced more than 100 km south - west, and touching the outer zones. During Pliocene - Quaternary was processed with the normal disjunctive, mainly along north - western border of Mirdita Tectonic Zone. In outer zones, at the transversal Drini Bay - Lezha Town, cut and displaced front thrust of the orogen [Sulstarova E. et al. 2011].

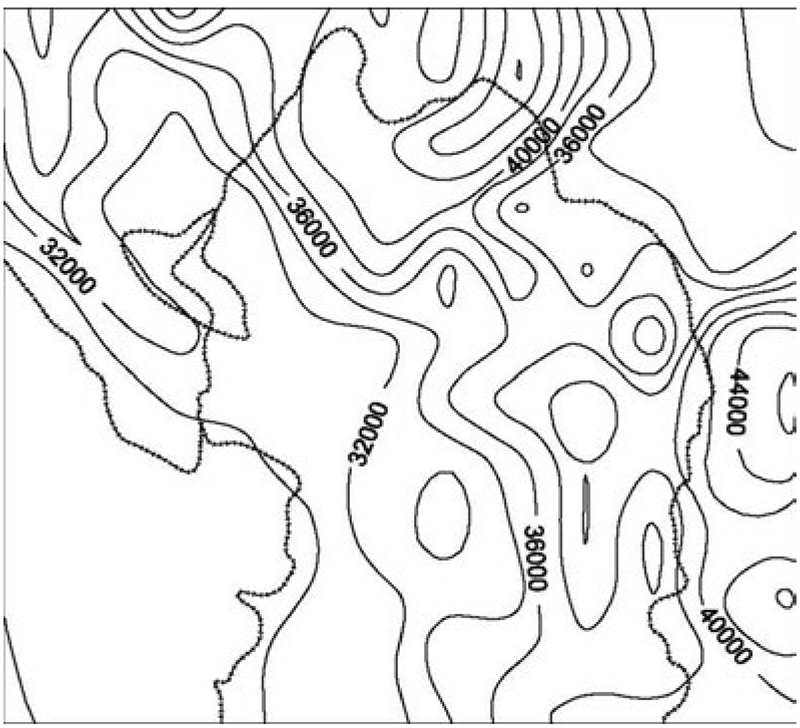
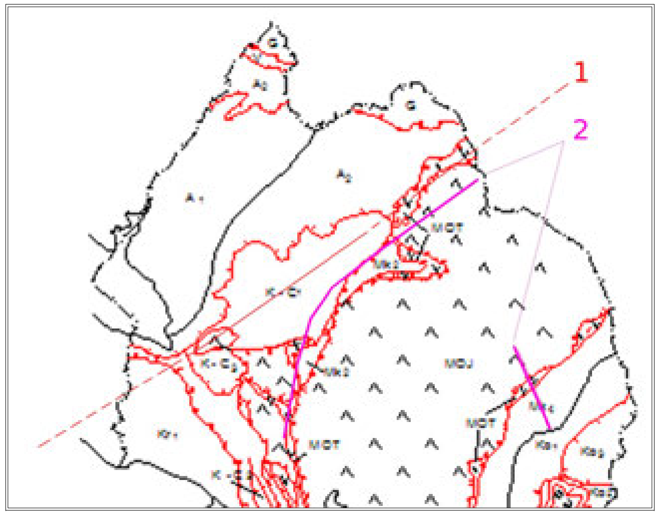


Fig. 2. Map of the Moho Discontinuity depth calculated by the Geiss relation [Koçiu S. 1989] using the Gravity Map of Albania [Bushati S. 1988].

Fig. 3. Tectonic scheme of the Albanides [Xhomo A. et al. 2002].
G-Gashi zone; MOJ- Mirdita ophiolites; MOT-T2-J3 Ophiolites (Efusive-sedimentary formation): Ko, Ko1, Ko2-subzones of Korabi zone; MK4 Gjallica subzone; Ao, A1, A2 sobzones of Alps zone; K-C1- Cukali subzone; K-C2- Krasta subzone; Kr1- Dajti subzone of Kruja zone.
1. The trace of the deep transversal thrust Shkodër-Pejë after gravity inversion,
2- Thermal anomaly axis of the Heat Flow Density value mW/m2 ;
3- Strike-slip faults Gjiri Drinit-Lezhë.



Offshore seismic surveying at the Montenegrin Adriatic shelf and deep wells [Dragasević T. 1983, Picha F.J. 2002] very well have enlightened geological setting at the depth on the western edge of Shkodër-Pejë deep thrust in the Adriatic shelf (Fig. 6, 7). Deep fractures in this region represent a wide zone with the presence of different fault branches, arising out of the common trunk that comes from deep.

Onshore geological surveys from Adriatic coast line-Shkodër-Cukal-Tropoja have mapping two regional disjunctive tectonics in northern southern borders of Cukali subzone, divided this subzone from Alps zone and Mirdita zone, respectively (Fig. 4).

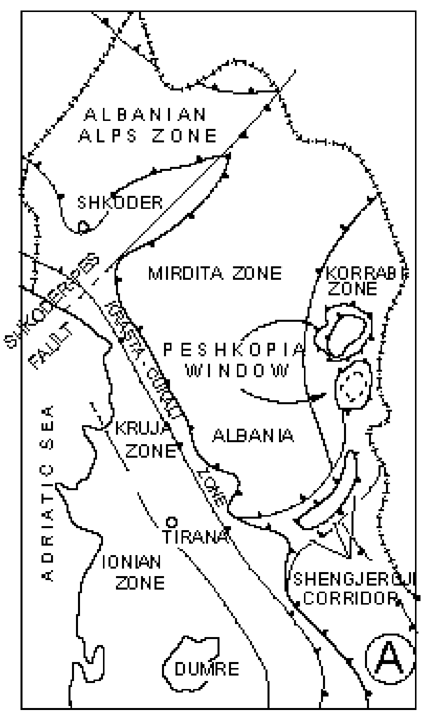


Fig. 4. Shkodër-Pejë deep transversal fault [Collage A. & Cadet J.P., 1991]

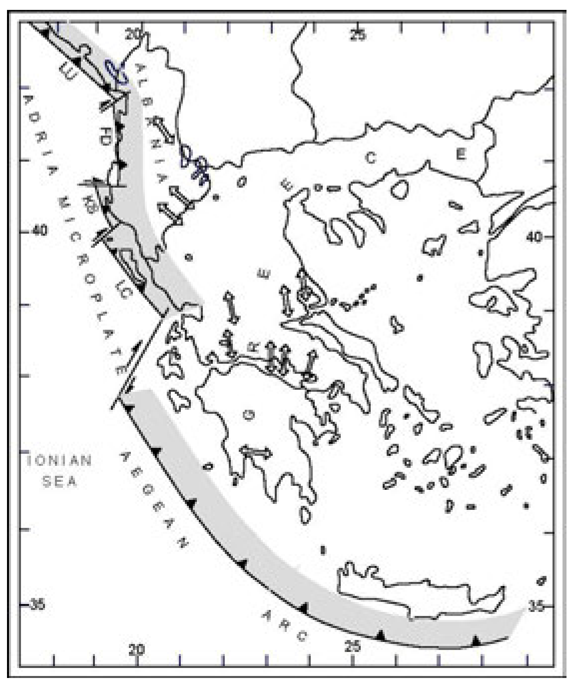


Fig. 5. Southern convergent margine of Eurasia plate: Adriatique collision and Aegean Arc [Aliaj Sh., 2006].Convergent margine segments: LU- Lezha-Ulqin; FD- Frakull-Durrës; KS-Karaburun- Sazani Island; LK-Lefkas-Corfu Island.

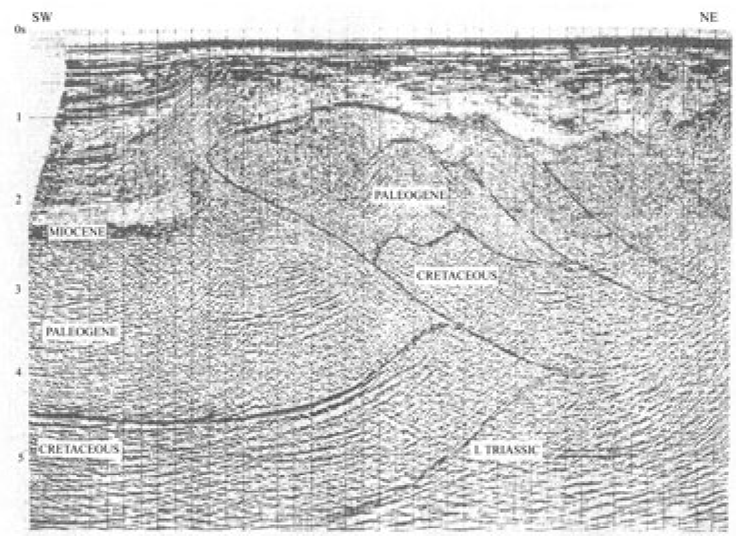
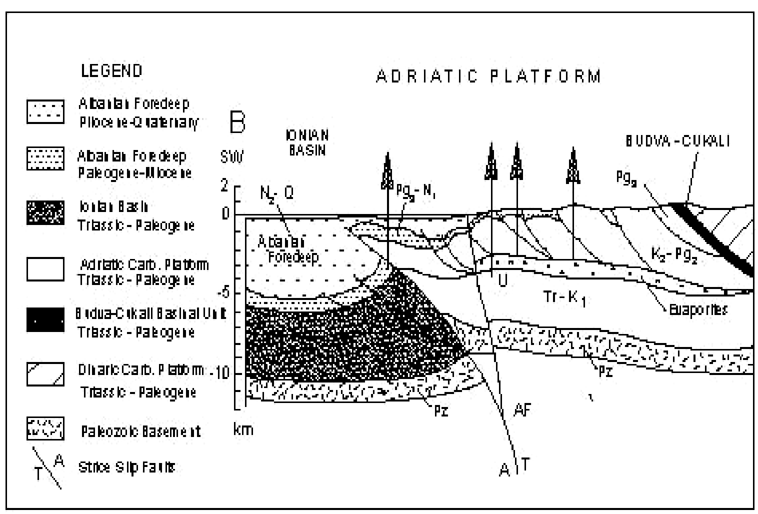


Fig. 6. Seismic section through area of Boka Kotorska perpendicular to the coastline [Dragasevic, 1983], showing the over thrusting of the buried orogen front over the South Adriatic Basin

Intensively folded structure of the Cukali subzone has northwest-southeast strike. They are cut transversally by Albanian Alps zone, at the north, and Mirdita zone at the south. Cukali zone, itself, is suppressed as an accordion -by these mentioned above two zones, during their overthrusting toward west and southwest. According to the estimation by the palinspatic opening of the Cukali folds, result that the displacement of its northwest edge toward the west-southwest is at least xxx km. After this geological mapping, in the Cukali subzone (sensu stricto), had not been observed any evidences of disjunctive tectonics of the Shkodër-Pejë tranversal fault [Qirinxhi A. et al. 1983].

From surface geological data, ranging from the Permian rocks of Albanian Alps tectonic zone, the Upper Triassic - Maastrichtian- Paleocene - Eocene rocks in Cukali subzone, and also from all magmatic and sedimentary rocks that spread of the Mirdita zone at the surface, had not been deduced any arguments which can help to accept the presence at the surface of the Shkodër-Pejë transversal fault. There are not any phenomenon of their influence for paleogeographic and paleotectonic of these zones [Qirinxhi A. et al. 1983].

Fig. 7. Cross section BB', interpreted from wells and seismic lines, shows the relation between the frontal zone of the thinned thrust belt, consisting of a series of shallow anticlines, apparently detached within the evaporitic horizon, dissected by the younger strike-slip fault, also shown the juxtaposition of the deep side of the Pliocene-Quaternary Albanian fore deep toward the Adriatic strike-slip fault system [Pica F.J., 2002]. AF - Adriatic strike-slip fault system; U - Lucan deep structure; A/T direction of strike-slip motion: A- away; T- toward.



In contrast with surface geological surveys, the gravity and magnetic surveys, seismological, and geothermal studies have provided information on the presence of this regional transversal deep thrust, and consequences of its action for geological history of the Albanides setting, which will

analyzed below.

In these conditions the alternatives of characterisation of this transversal fault as a transform tranversal fault, aligned with the overthrust tectonic in the northern boundary of the Mirdita zone [Kodra A. et al. 1994, Xhomo A. et al. 2002], or as a tectonique border between Cukali and Alps zone as natural geological border between them [Papa A. et al. 1991] have not support by geophysical and remote sensing data.

3.2. Gravity and Magnetic field scattering

Scattering of gravity and magnetic fields have very well contoured Inner Albanides, particularly the ophiolitic belt (Fig. 8, 9). Bouguer gravity anomaly and magnetic ones have common peculiarities: a) epicenters are located over the eastern belt of the ophiolites; b) Ophiolitic belt represented in two parts: northern and southern, separated by flyschoid corridor; c) gravity and magnetic anomalies are very intensive, compared with Internal Albanides. These pecularities and anomaly configuration have argued the nape character of the ophiolitic belt [Frashëri A. et al. 1991, 2010].

According the gravity and magnetic surveing (Bushati S. 1987), Alps zone represented by a minimum of Bouguer gravity anomaly in general, with particularly a small amplitude anomaly in southern part of the Alp's zone (Fig. 8). In the northern direction there are observed the trend of the increasing of the intensivity of magnetic anomaly. This pecularity of the magnetic anomaly express overthrust character of the Albanian Alps, too. Over the Cukali subzone is observed a linear upward trend of the intensity of the Bouguer anomaly toward the Mirdita zone (Fig. 8, 10). This trend's anomaly can explained by the presence of the vertical deep tectonic thrust.

After the inversion model, thrust level resulted with amplitude about 4km in the Moho Discontinuity (Fig. 10). Thrust amplitude toward the Earth's surface is gradually reduced and, until the surface of the Earth, is almost extinguished, also according to the geological mapping. This deep thrust represents Shkodër - Pejë fracture. By analogy with the deep strike-fault in the Adrietic Shelf Crust (Fig. 7) and this, Shkodër - Pejë deep fracture, at the depth expected to be composed by several branches, occupying a wide zone of their influence and action.

3.3. Paleomagnetic surveys - an important indicator of the presence of Shkodër - Pejë deep fracture and its geodynamic evolution role in Alpine Mediterranean Foldet Belt Hellenide-Albanides-Dynarides

Dynamic evolution of the Northern Albanides has its reflection in paleomagnetic data, collected from the paleomagnetic studies in Albania, which were performed during 90 years, performed by Mauritsch H.J. et al. (1991-1995), Kissel C. et al. (1992-), Muttoni G. et al (1940), Frashëri A. and Bushati S. (1995) [Frashëri A. et al., 1995; Kissel C. et al., 1995; Mauritsch H.J. et al., 1995, 2006, Mauritsch H.J. 2000, Muttoni G. et al. 1994, Speranca F. 1995].

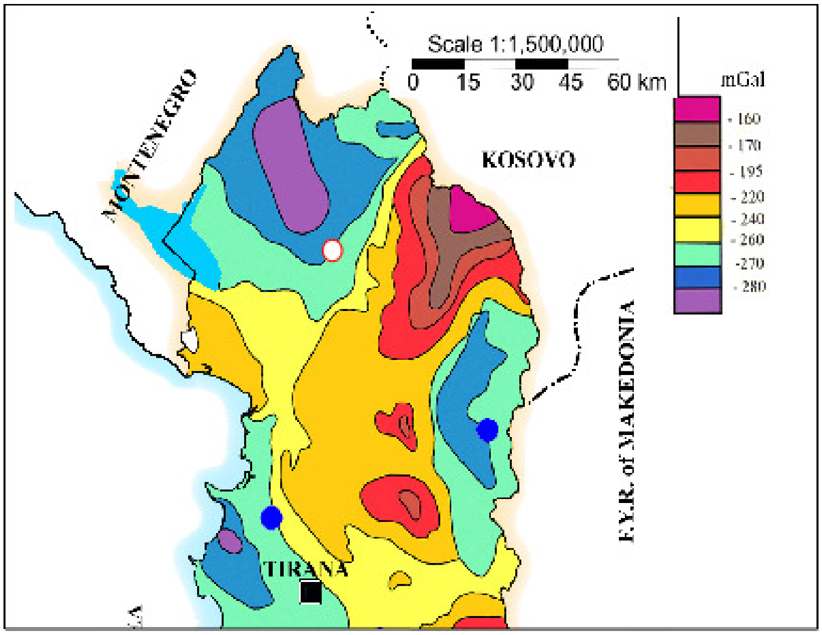


Fig. 8. Gravity Bouguer Anomaly Map of Albania [Bushati S. 1988]

Paleomagnetic studies shows that Ionic and Kruja tectonic zones, located at southern side of the Shkodër - Pejë transversal, have support a joint clockwise rotation, with an angle 45-50^{o} during and after Eocene-Oligocene period. This rotation has been realized through two phases, by 25^{o} every phase in the middle Miocene up to Plio-Pleistocen. Ionic and Kruja zones don't have any different rotation between each other. Clockwise rotation for 40^{o}-45^{o} since Early-Middle Miocene is observed at Kçira site. For this rotation, the Kçira pole acquires a West Gondwana affinity [Mutoni G. et al. 1996]. A large Neogene clockwise rotation, D=40^{o}, I=3.8^{o}, is observed also in the Mirdita zone of Inner Albanides, at southern Albania, northern of Albanian-Greek border [Mauritsch et al., 1994].

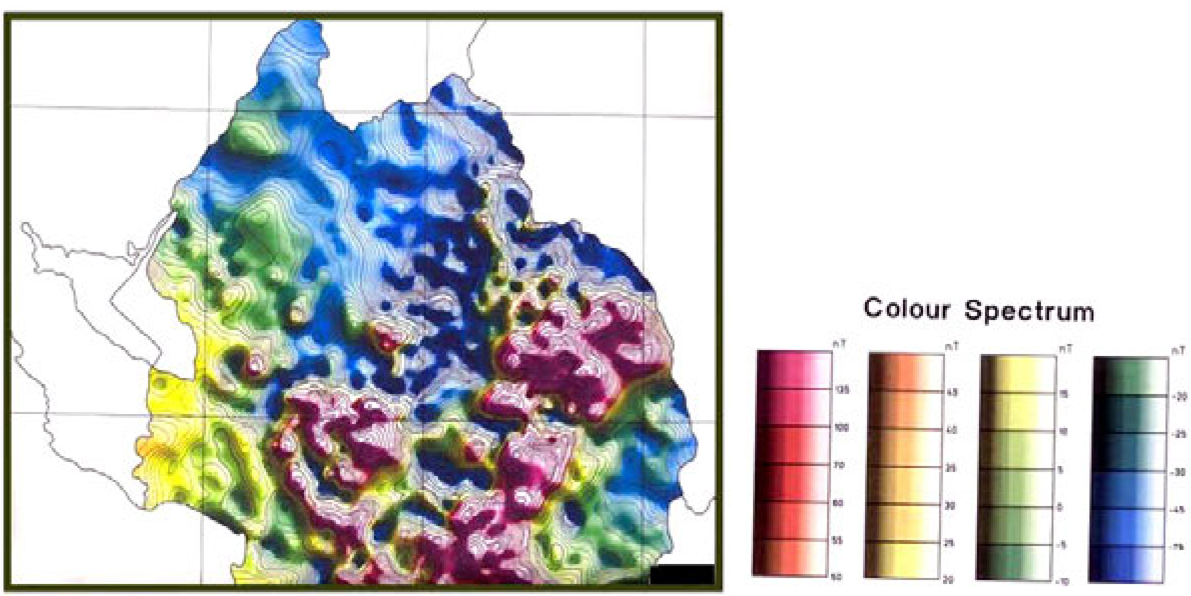


Fig. 9. Magnetic Anomaly Map of Albania [Bushati S. 1998]

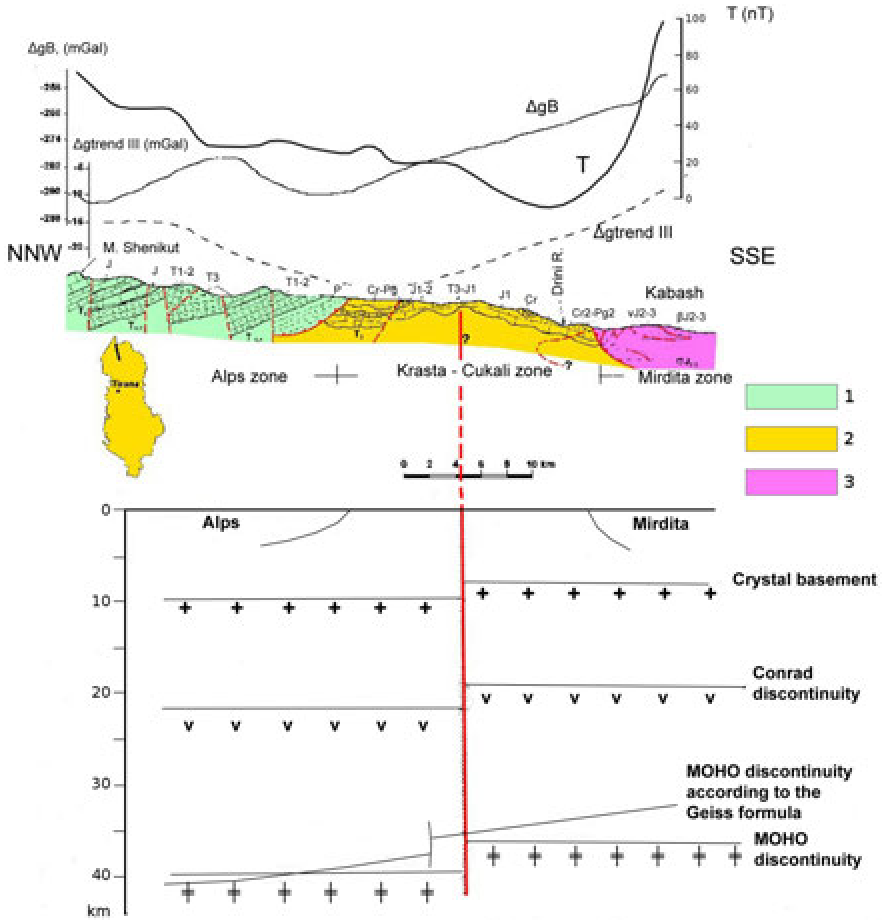


Fig. 10. Gravity Bouguer Anomaly (Δg) and Magnetic Anomaly (T) profile I-I, Mountain Sheniku at the Albanian Alps-Kabash in Mirdita zone, and gravity inversion results.

Eocene limestone anticlines of the Renz and Kakariq area, which are located in southern side of the Shkodër - Pejë transversal zone, have a rotation about 31^o. Consequently, these two anticlines have a declination with 18^o smaller than the declination of the Eocene limestone in the Central Albania. These two anticlines maybe have superposition of two rotations with inverse sense: clockwise rotation of 50^o, which has been subdued all External Albanides structures and local counterclockwise rotation by 25^o, which has rotated only these two anticlines that have a Dinaride strike.

At the Komani area, in the southern side of Shkodër - Pejë transvesal, at north-western edge of the ophiolitic belt of Mirdita zone, have been observed declinations, which show the 82^o-140^o clockwise rotation of the Jurassic limestone. The same 28^o-57^o clockwise rotation is observed for ultrabasic rocks of western edge of the Gomsiqe massive, at south-western direction from Komani (Fig. 11).

Gabro massive at Bozhaj, southern of Korça city have a magnetization vector with declination $Do=282^o$ and inclination $Io=60.9^o$, the same direction as in the Khalkidhiki in Greece ($D=240^o$-312^o and $I=30^o$-68^o), which have demonstrated an Upper Cretaceous anti-clockwise rotation, and Upper Tertiary clockwise rotation of the Khalkidhiki [Feinberg H. et al. 1996].

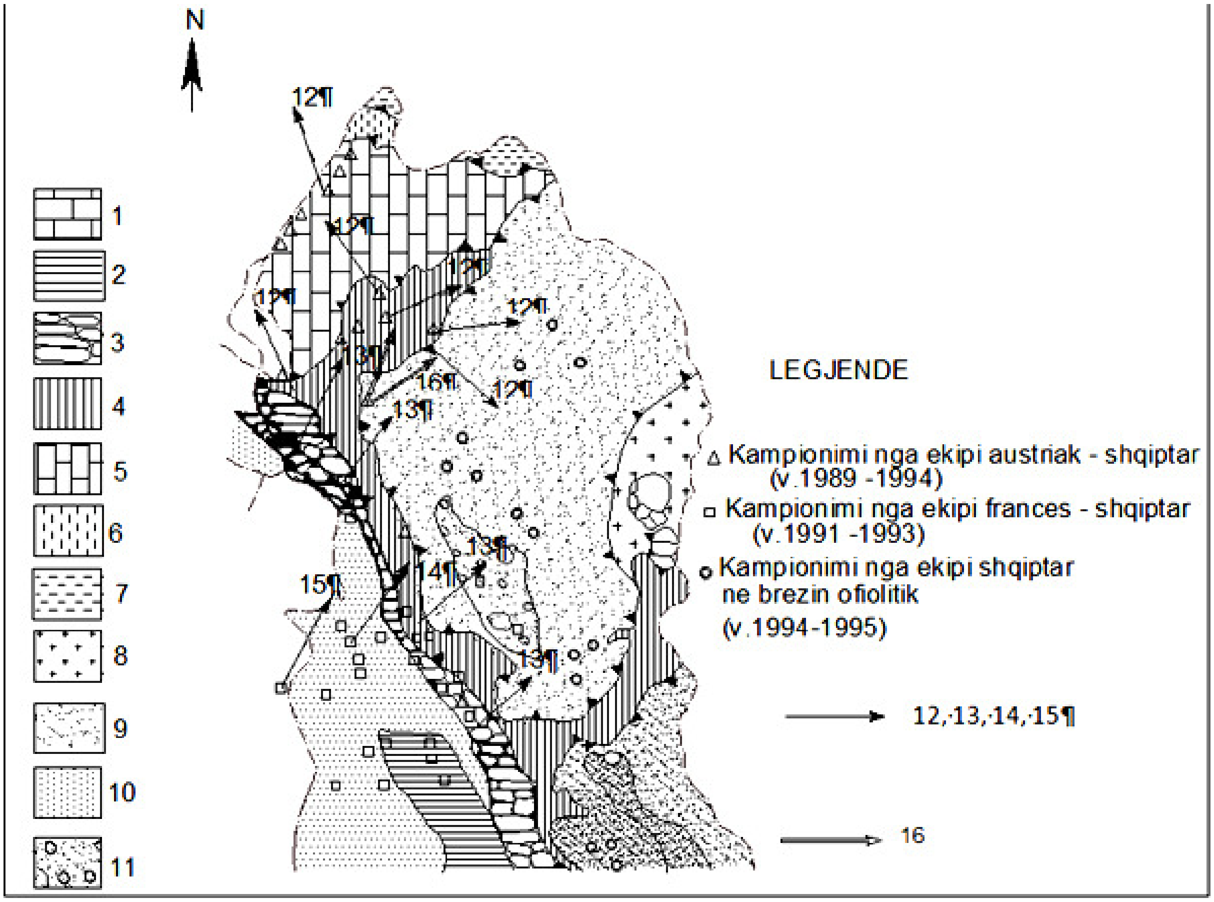


Fig. 11. Scheme of the paleomagnetic echantionage in Northern Albania, during 1989-1994.

1-Sazani Zone; 2-Ionian Zone; 3-Kruja Zone; 4-Krasta-Cukali Zone; 5- Albanian Alps Zone; 6-Vermoshi Zone; 7- Gashi Zone; 8-Korabi Zone; 9-Mirdita Zone; 10- Periadriatic Depression; 11-Mollasic depressions; 12- Jurasic limestone; 13- Upper Cretaceous-Eocene limestone: 14- Middle Neogene molasses: 15- Pliocene formation: 16- Ophiolite.

Limestone samples from Albanian Alps at Selca area, in the north of Shkodër - Pejë transversal, shows a counterclockwise rotation for 20^{o} in relation with present north, the same value as in southern Dinaride's structures. The analogue counterclockwise rotation as in Selca area, have also Jurassic limestone at southern Shkodra lakeshore. This fact shows that both these sections appertain to the same tectonic zone, in northern of Shkodër-Pejë transversal area.

The Kotori to the Split area, which belongs to the Dinarides in Dalmatia in the North is almost immovable for the time period being studies starting from the Eocene onwards. Dinaride's orogen in the north are characterized by the regional direction f the structures N12^{o}, unlike the Albanides orogen structures with a direction N150^{o}, as in southern Hellenides [Kissel C., 1994; Mauritch H.J. et al 1993, 1995, 2006; Mauritch H.J. 2000]. Paleomagnetic studies in the external Dinarides have shown that this orogen has no any significant counter-clockwise rotation in relation to Africa, ranking from the Eocene, such small rotation that is observed in limestone of the Albanian Alps to the southern shore of Shkodra Lake.

Paleomagnetic directions demonstrate a strong tectonic disturbance in the Central part of Shkodër - Pejë zone. In the Jurassic limestone of the northern side of Cukali subzone, about 4 km northwest of Prekali village, is observed a country-clockwise rotation for about 45^{o}. Only in less than 2 km

south, a 60° clockwise rotation is observed. Such result attests to the strong tectonic influence in transversal thrust zone.

Paleomagnetic studies have demonstrated that Shkodër - Pejë belt presents a transition zone between counter-clockwise rotation in the north, and clockwise rotation in the south sides (Fig. 11, 12). Consequently has a great tectonic influence over Cukali subzone. Thus, Shkodër-Pejë lineament, defines a transition zone which separates the Albanian Alps and the Dinarides (counterclockwise rotation), from Albanides and Hellenides (clockwise rotation).

For the rotation pole located at Shkodër - Pejë transversal thrust, Southern Albania has undergone a horizontal displacement is about 173 Km [Speranza F., 1995].

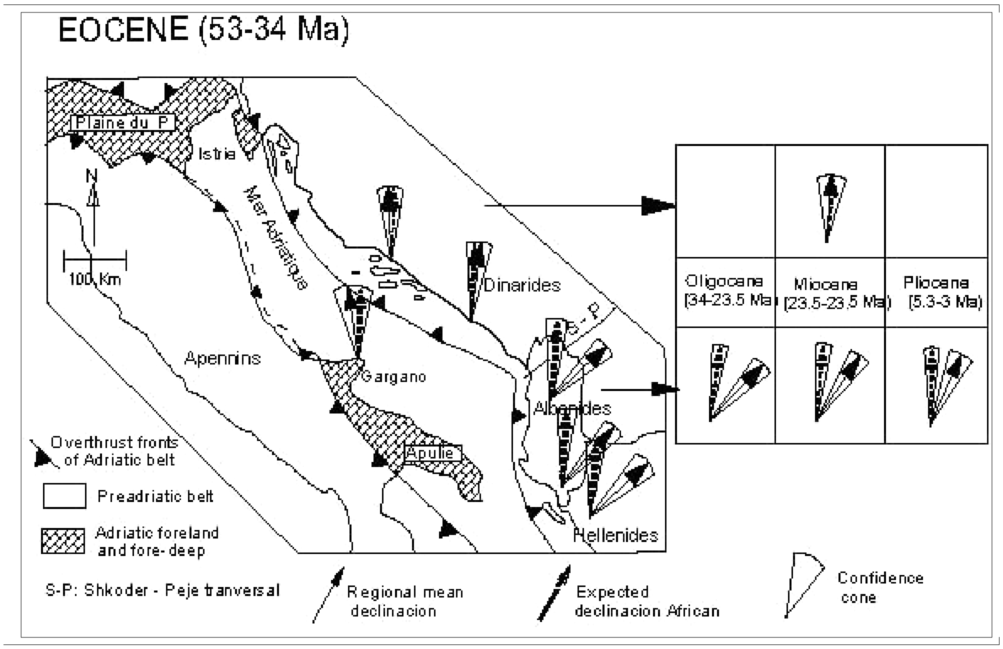


Fig. 12. Regional Paleomagnetic Declinations around Adriatic Sea and expected paleomagnetic declination for Africa during the Eocene-middle Pliocene period (Speranza, 1995).

3.4. Seismological pecularities related to Shkodra-Peja seismoactive tranversal fault zone

Seismological studies carried during the last half of century in Albania have mapping seismoactive longitudinal and transversal deep tectonic fault zones of the Albanides (Fig. 13 and 14).

Among them is situated the Shkodër - Pejë transversal fault zone, which represent a seismoactive transversal normal fault zone There are systematic misallocations of the earthquakes (between zones 4-5, fig. 13-a, or one Nr. 4 in fig. 13-b), with strong lateral velocity contrasts, with a difference across the fault about 3-7%. It is well delineated also by present-days seismic activity. His more intensive activity, after relatively strong earthquakes, it appears in zones where interrupted by longitudinal faults. The following earhtquakes have been recorded in the Shkodra-Peja fault zone: Peja, Io=VIII, Febryary 11, 1662; Shkodra, Io=VIII, July 3, 1855, and 1 June 1905; Trush-Shkodra M=5,5, August 27, 1948; Ulqini, 1444, and M=5,5, November 3, 1968. During the period 1976 - 1992, in some segments of the fault zone, were evident lots of micro and small earthquakes with a magnitude Ms≤5.0, mainly as clusters of earthquakes (Muço B., 1984; 1991, Sulstarova S. et al. 2011). The expected seismic potential of this seismogene zone is of a Mmax=5,5 to 6,0 [Sulstarova S. et al. 2011].

Shkodër - Pejë transversal fault zone divided in two segments the northern part of the Ionian-Adriatic thrust fault zone, which presented the longest fault zone along the Adriatic and Ionian

coasts:

a) Lezha town in Albania - Ulqini in Montenegro coastline Northern segment, WNW trending. This segment is more than 200 km long, including Northern side of Kruja tectonic zone in Albanides and Southern part of Dalmatian zone in Montenegro.

b) Lezha town-Vlora city, with an N to NNW trending. This segment, which is situated along Periadriatic Depression and stroked by Adriatic coastline, is about 130 km long.

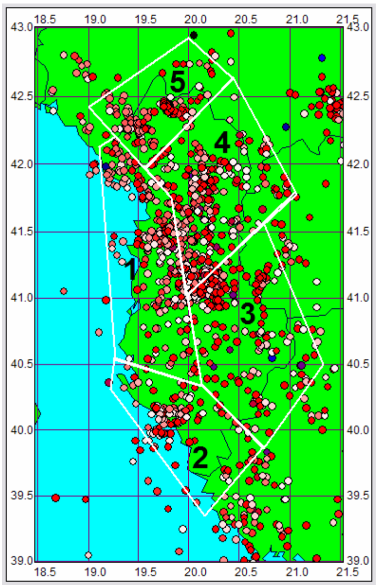


Fig13-a. The map of seismogenic zone and the earthquakes epicenter, occurred in the period of time 2002-2006, where the models of velocity of the Earth crust are calculated [Aliaj Sh. 2000]

Fig. 13-b. Map of the seismoactive zones in Albania, with maximal Albania [Aliaj Sh. 1988].

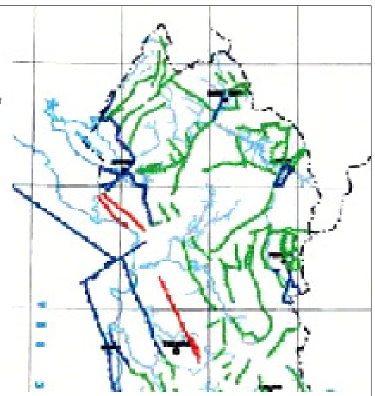


Figure 14. Map of active fault zones in Albania [Aliaj Sh. 2000]

Based on focal mechanism solution, results that in Northern littoral side of the Shkodër- Pejë fault zone, the compression strain has a P=16^0 NE-W strike, and 10^0 plunge, while the axis of expansion T = 124^0 and 79^0 dep. In the Southern side of the Shkodër- Pejë fault zone, the compression strain has a P=274^0 E-W strike, and 10^0 deep, and the axis of expansion T = 164^0 SE-NW and 64^0 deep (Sulstarova, 1988, Tagari (1993). In the internal area, region Vau i Dejes-Pukë-Tropojë, the tensional stress regime has a NWN extending (Muço B. 1994, Sulstarova 1988). Axis of expansion have a strike direction NNE T=140, and compression axis SSE-NNW P=152^0 and 74^0 dep. The focal mechanism solution of November 21, 1985 earthquake with Mw=5,6, generated from Lezha strike-slip, shows that this fault acts as a dextral transpression strike-slip stress axis P-207^o/30^o and T-94^0/33^0 [Muço B. 1994, Aliaj Sh. 2000]. This fault there presents the SW edge of Shkodra - Peja transversal fault zone in the internal domain of compressional regime. The existence of Lezha transversal as a important element, that cut and transfer the orogen front is testified not only from geologic-geophysical and seismological data, but also from GPS ones [Sulstarova et al, 2011].

Offshore geophysical explorations have discovered a deep fractures zone in the Adriatic Sea between Buna River discharge and Kotorri Estuary, about 15-20 km from coastline, with the NW strike direction. In this Adriatic ofshore area, near Albanian-Montenegrin border, at the northern side of the Shkodra - Peja fault zone, was located focus of earthquake, 15 April 1979. According to

the scattering of his aftershocks, the focal dimensions are: longue 70 km and width 25 km. Focal zone, as a narrow belt, has a NW-SE strike direction from Ulqini city to Kotorri Estuary (Sulstarova E. et al. 2011). Thrust fault plane has a NW 500 strike direction, with NE 160 plunge, while slip vector has a NE 48^o direction, slipping angle $\lambda = + 16^0$, axis of the stress $P=46^o$ SW with 28^o deep, and $T=52^0$ VL and 62^0 deep [Sulstarova E., 1983; Sulstarova E. et al. 2011].

The analyze of the seismic P waves velocities (Vp) and ratio Vp/Vs show that exist a difference 0,12-0.46 k/s between upper part of the Earth Crust (0-30 km) in the both side of the Shkodra-Peja fault zone [Ormëni Rr., 2010]. Such difference presents a 1,9-8,5 % of the Vp size. At the greatest depths, 30-45 km the difference is insignificant.

The stress field, the fault system and the spatial distribution of the seismic activity shows that the Albanian territory and the surrounding areas is constructed by many blocks which move relatively to each other due to the collision of two great plates, the Eurasia and African ones, in the region of the Adriatic promontory of African plate [Sulstarova et al. 2011].

All seismological features indicated above argues that Shkodra-Peja transversal present a deep fracture, a relatively wide active fault zone that separates the paleogeographic units with different geological settings, and dynamic of their developments.

3.5. Heat Flow density anomalies

Geothermal studies at Northern Albania have been performed in 19 boreholes and in one deep well. As for the whole territory of Albanides, even in northern their part extends Heat Flow Density anomaly. Their axes are presented in Fig. 3. There are there heat hearths. Two of them, in Ragami in Tropoja and Karma-Palaj are located in the unic axis, which extends from northeast to southwest, over the overthrust tectonics in the northern border of the ophiolitic belt. Thirty axes is located in Keçel village in eastern site of the Kukesi ultrabasic massif. The heat flow density values are up to 60-70 mW/m^2. Radiogenic heat generation of the ophiolites is very low. In these conditions, increasing of the heat flow in the ophiolitic belt is linked with heat flow transmitting from the depth. Ophiolitic belt Heat Flow Density highest value can be explained by the small thickness of the geological section down to the top of crystalline basement, and MOHO discontinuity. The granites of the crystalline basement, with the radiogenic heat generation, represent the heat source. Heat flow anomalies are conditioned by intensive heat transmitting through deep and transversal fractures. Distance between trace of the Shkodër - Pejë thrust and thermal anomaly axis is 9 km. Thermal anomaly is located on the mounted side of the fracture, where the crystalline basement top is located in lower depth than on the sitting side of the fracture.

By comparing these characteristic of the thermal field and zone geological setting with structure of the strike-fault system in southwestern side of the Shkodër - Pejë transversal in Adriatic Shelf, we assume that this thermal anomaly associated with the branches of transversal fracture.

3.6. Offshore geothermal information

Heat flow density anomaly in the Adriatic See shelf, has been presented “Geothermal Atlas of Europe”, 1992, (Fig. 15). The thermal anomaly over the Adriatic Shelf, with epicenter in Drini Bay is linked with Adriatic strike-slip fault system. In the same time, this thermal anomaly epicenter is located over the prolongation into Albanian Adriatic Shelf of Shkodër - Pejë transversal deep fracture. These facts show that the Shkodër - Pejë transversal deep thrust continues even in the Adriatic Shelf, where interrupted with Adriatic longitudinal strike-slip fault system. Over their intersection node is located thermal anomaly, which is linked with heat flow from Crystalline Basement through these deep fractures.

Fig. 15. Adriatic Heat Flow Density Anomaly [Geothermal Atlas of Europe, 1992] (a), and correlation of the thermal anomaly with trace of the Shkodër-Pejë transversal deep fracture (b).

3.5. Remote sensing and GIS information

First study by Landsat imagery, conducted Chorowich J., Cadet J.P. and Stephan J.F. [Chorowich J. et al. 1981], for disjunctive tectonics in Northern Albania, include Shkodër - Pejë transversal fault. In fig 16 are presented a sketch of thrust tectonic in Northern Albania, which differenced clearly main segments of Shkodër - Pejë transversal fault.

Fig. 16. Major tectonic accidents in northern and southern side of the Shkodër-Pejë transversal accodin to the landsat data [Chorowich J. et al. 1981]

Based on GIS and seismological investigations are determined velocities of microplates movement in Adriatiuc Sea. Nubia (Africa) microplate is moving NW with respect to Eurasia with a velocity of 6 mm/yr, while the Adria microplate moves NE at a rate of 4-5 mm/yr (Fig. 18) [Battaglia M. et al. 2004]. For Nocquet J.M., Adriatic is an independent microplate within Nubia – Eurasia plate boundary one [Nocquet J.M. et al. 2001]. Oldov et al. (2002) propose that Adria is divided by Gargano-Dubrovnic fault in two blocks. Northern Adria has little or no motion relative to Europe and its part of Alpine collage of Southern Europe. Southern Adria is moving with Nubia and is continuous from Sicily to Apulia, [Oldov J.S. et al. 2002].

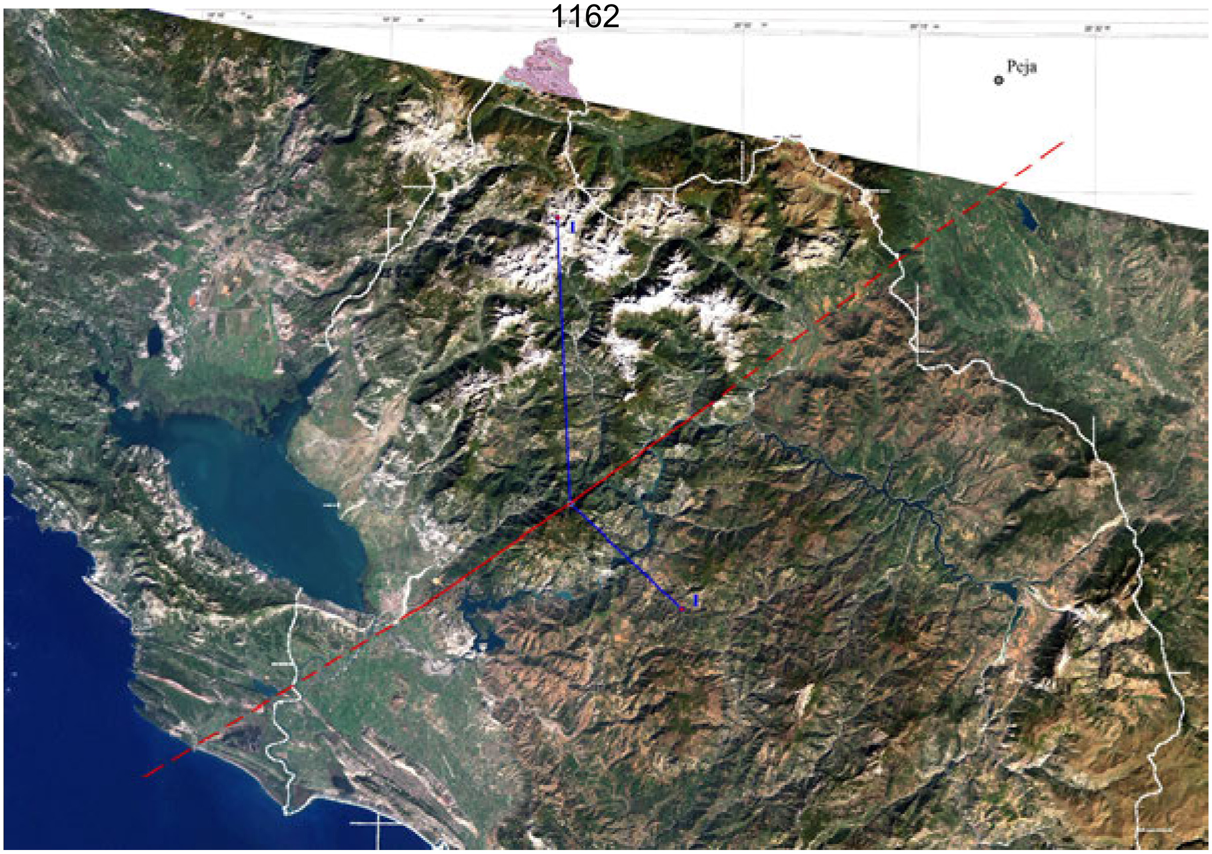


Fig. 17. Satelite image of Shkodër-Pejë transversal fault at Northern Albania.

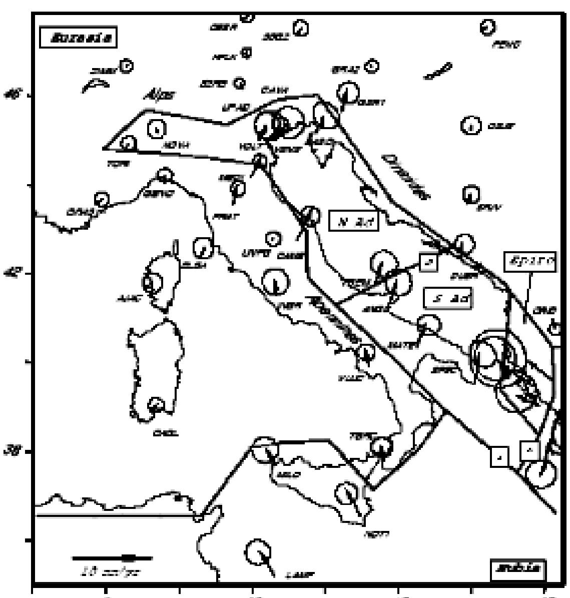


Fig. 18. Location of the segments (solid lines) and blocks used to model the Adriatic Region. [NAd] North Adria, [Sad] South Adria, [G] Gargano-Dubrovnik fault zone, [K] Kefallinic fault zone, [A] Apulia escarpment. GIS velocities and their 95 confidence ellipses. The grey dots indicate the location of the shallow seismicity from 1975 to 2000 (M>3.5) [Battaglia M., et al. 2004].

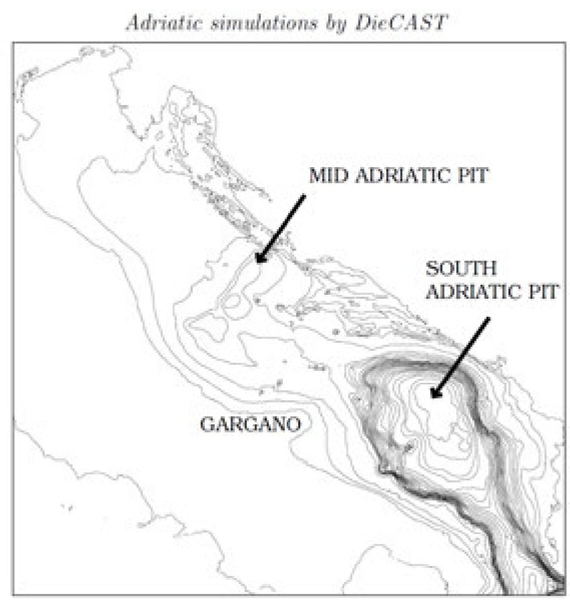


Figure 19. Contour plot of the bathymetry of the Adriatic Sea with horizontal resolution of 1 min. The Mid Adriatic Pit is the relatively deep region which nearly transects the Adriatic. The contour interval is 50 m. [Dietrich D., et al., 2002].

In the frame of these interpretation data is necessary to discussed also the position of NW edge of Otranto Street, which is located in the direction of the Shkodër-Pejë deep transversal fault in the eastern Adriatic Shelf, that result parallel with Gargano – Dubrovnic fault zone (Fig. 19).

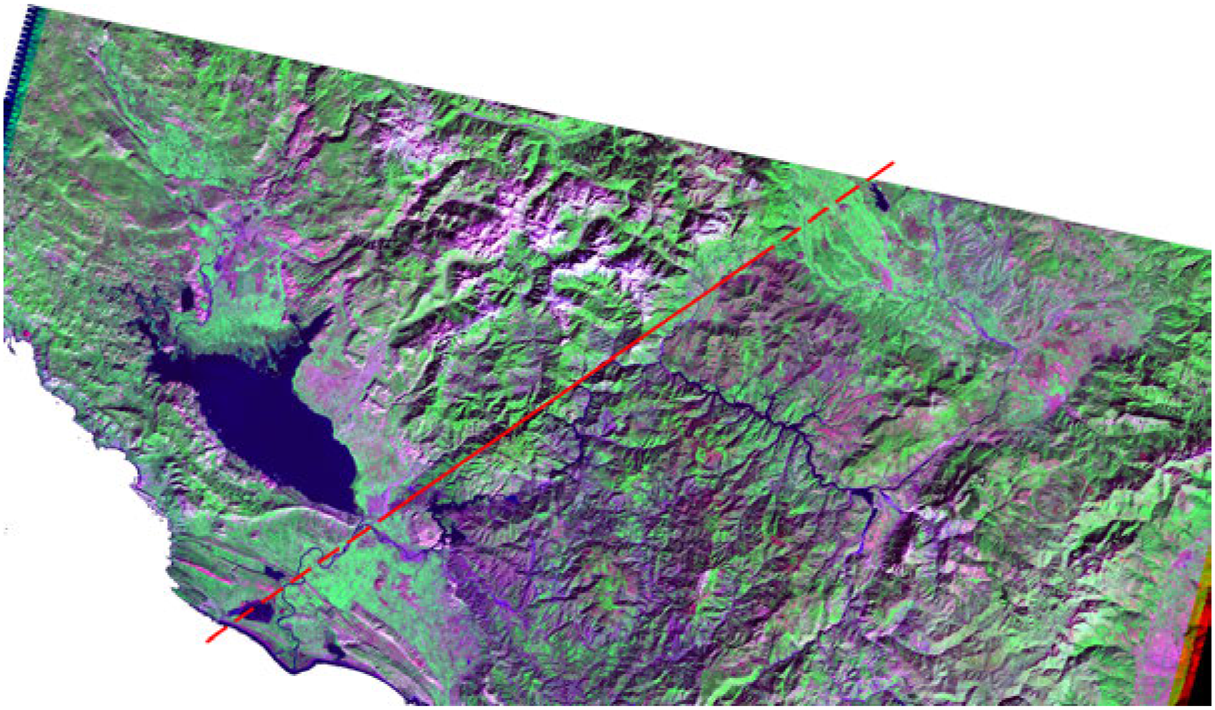


Fig. 20. Combination of Landsat bands 7 ~ Red, 4 ~ Green, 2 ~ Blue.
Green areas represent the vegetation coverage.

Usage of satellite imagery for identification of geological structures resulted difficult because of two factors: vegetation coverage of the area and soil coverage of rocks. Nevertheless in different band combinations from Landsat it is possible to distinguish two areas separated during the same delineation of Shkodra – Peja fault (Figure 20 represents in false colors the area from Landsat7 images with the band 7 as Red, band 4 as Green and band 2 as Blue).

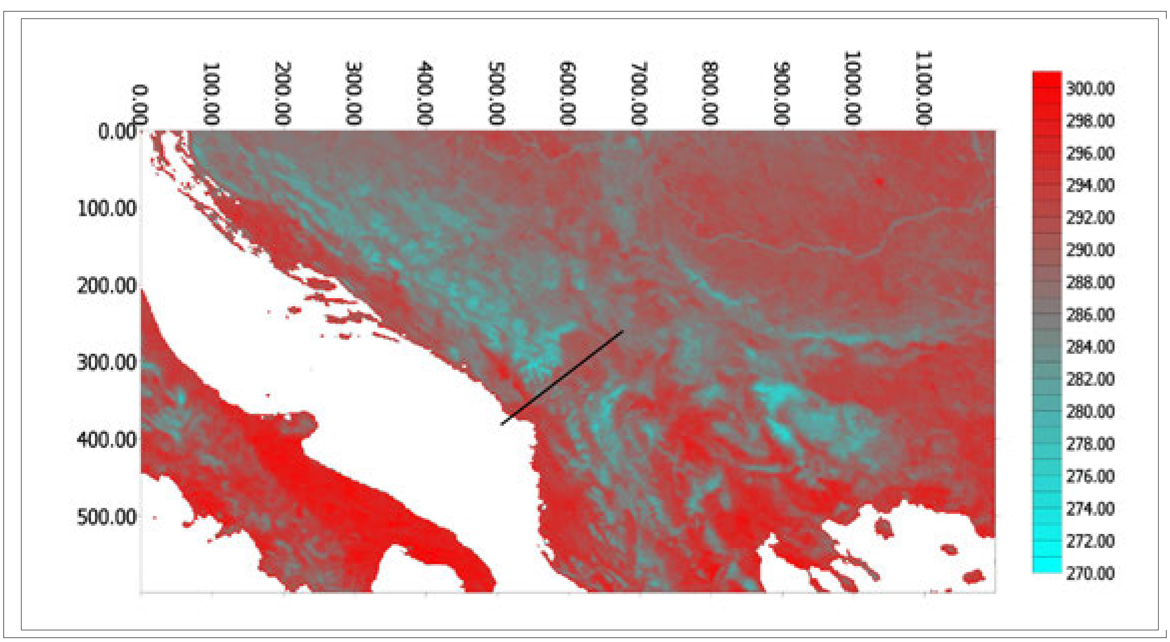


Fig. 21-a. Average of daily ground temperature for the period 2004 – 2006 from MODIS images

Analysis of ground temperature from MODIS images was done calculating the average for day and night temperatures from 24 images spanned in the period 2004 – 2006. In these images it is visible a “bridge” of relatively higher temperature delineated between Shkodra and Peja (Fig. 21).

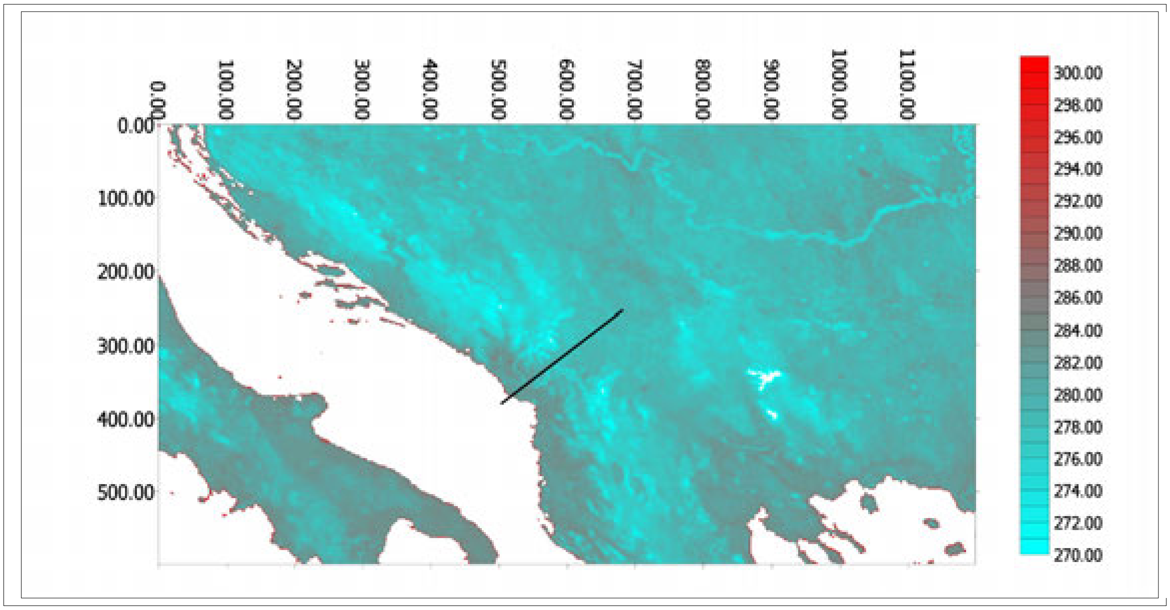
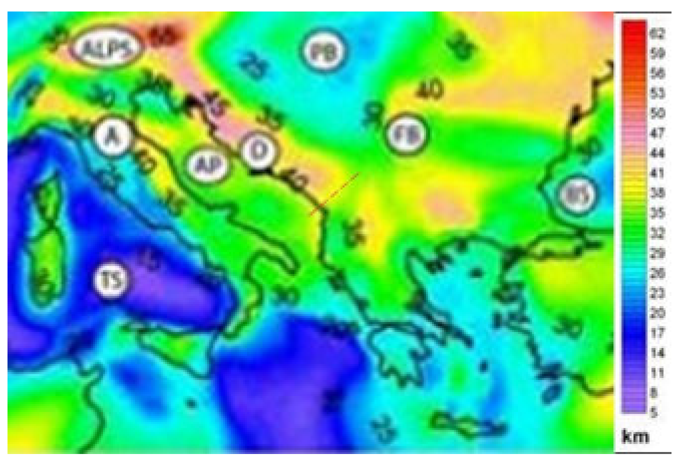


Fig. 21-b. Average of night ground temperature for the period 2004 – 2006 from MODIS images

At the end of our analysis on the Skoder-Peje transversal thrust we find reasonable to confront our results with new reference of the model for European crust, EuCRUST-07 (Mahdala Tesaauro et al. 2008). As is evident from Fig. 22 , which represents map of Moho depth, is very clear existence of the transversal Shkodër-Pejë belt with reduced Moho depth, which is a determining argument for the presence and nature of its.

Fig. 22. Moho depth (km), EuCRUST-07: A new reference for the European crust (Teasuro M. et al. 2008)



4. Conlusions

1. Earth Crust of the Albanides exhibits a block structure controlled by a system of NW-SE longitudinal faults as well as transverse ones. The blocks have different thickness.

2. According to the gravity data inversion, Shkodër-Pejë zone present a vertical deep transversal fracture, which separate two Earth crust blocks. Fracture interrupts the MOHO Discontinuity with amplitude about 4 km that decrease towards the Earth surface. This fracture represents a

seismically active belt. Based on satellite image, this vertical fracture outcropped through Cukali subzone.

3. Paleomagnetic studies have demonstrated that assemblage of the Albanides margin encountered a clockwise rotation of about 45^{o}, after upper Oligocene. This rotation happened in two phases. This is also the case for the Western margin of the Hellenides. Shkodër-Pejë transverse fault represents a transition zone between the clockwise rotation of the Albanides and Hellenides and the counterclockwise of Albanian Alps on e and Dinarides. For the rotation pole located at Shkodër-Pejë transverse fault, the horizontal displacement is about 173 Km in Southern Albanian border.
4. Continuation of Shkodër-Pejë fracture in the Albanian Adriatic Shelf in Drini Bay passes over the epicenter of Heat Flow. This correlation argues relation of the geothermal anomaly with depth fractures of the Earth Crust in Adriatic Shelf.

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A REWIEV ON ANTHROPOGENIC IMPACT TO THE MICRO PRESPA LAKE AND ITS DAMAGES

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Abstract

Paper presents the results of the integrated and multidisciplinary studies for investigation of the anthropogenic damages to Albanian part of the transborder Micro Prespa Lake. Micro Prespa Lake is lake with international status, as Ramsar Convection, International Park and Special Protection Area-79/409/EEC. According to the studies, investigations and analyses, the following were concluded:

Devolli River- Micro Prespa Lake irrigation system was not scientifically supported by environmental engineering, hydroeconomy and International Rights principles. It does work according to the projected parameters, and also, doesn't supply the agricultural needs. About of 10 % of the water volume, discharges by Devolli River in Micro Prespa Lake during the winter, is taken from this lake for the irrigation in summer.

Great surface of Albanian part of Micro Prespa Lake is destroyed. The other part of the lake is atrophied and the habitat and biodiversity are damaged. Important and unique species of fish, birds and plants of national and international values are risked. The underground karstic connection ways for water circulation are blocked. There are ruining the historic values of the area, such the encient Treni cave from the Bronze Age. The Albanian part of the Micro Prespa Lake has been damaged by the human activities.

A huge amount of 1,2 million cubic meters alluvium has been deposited on the lake bottom and lakeshore, which was transported by the Devolli River waters, since 1974. This river waters, rich in alluvium and organic coal material from outcropped geological formations, also absorbed free chemical toxic remains by the drainage of Devolli farm ground, which have changed the chemical features of the lake water and degrading it. Micro Prespa Lake communicates with Macro Prespa Lake, and together with Ohrid Lake. Blockage of underground karstic connection ways has diminished not only the components of the lake water balance, but also the decreasing yield of the underground springs, that supply the Ohrid lake and drinkable water springs. The Albanian part of the Micro Prespa Lake plays the role of a gigantic decanter. This is an unprecedented case, not only in Albanian but also in Balkan and World hydrography.

Devolli river alluvium deposited in Micro Prespa Lake caused the otherwise of territory of Republic of Albania in this area. Albania will not have any part in this lake after some years. The social and public opinion in Albania, must be conscious for the otherwise of

Albanian territory, which in the case of Micro Prespa Lake has a national and international negative effect on destructions of a transborder lake, defendey by Europian Convents.

Key words: Macro - Micro Prespa and Ohrid Lakes System, anthropogenic impact

1. Introduction

The paper presents the environmental problems of Prespa Lake system, which is the pearl of Western Balkan region. This system is composed of Micro and Macro Prespa Lakes, and is the largest and important limnological object. Prespa Lakes have great and special ecological values. Its environment is characterized by a picturesque nature, particular climate, rich biodiversity, extremely complicated karstic hydrography, high transparency of dark blue waters and uncommonly diversified, beautiful coastline. In particular, the biodiversity of Micro Prespa Lake is very rich. Micro Prespa has high ecological values. Prespa Lakes have a very important influence in the general water balance of the Ohrid Lake. Prespa's hydrographic network is located in the three-state border area, i.e. between Albania, FYROM and Greece, which have the common interest for maintaining and recuperating the special natural hydro-ecological values of European dimensions in this area.

Micro Prespa Lake is lake with international status, as Ramsar Convection, International Park and Special Protection Area-79/409/EEC.The human activity impact on Prespa Lakes system and great damaged of the ecological values are analyzed in this paper.

2. General setting of the area

The study area is located in the Western Balkans, and it is part of three Lakes System: Micro Prespa, Macro Prespa, and Ohrid. These lakes are located at the foot of the rocky Dry Mountain (Mali Thatë), which has a maximal altitude of 2287 m (Fig. 1).

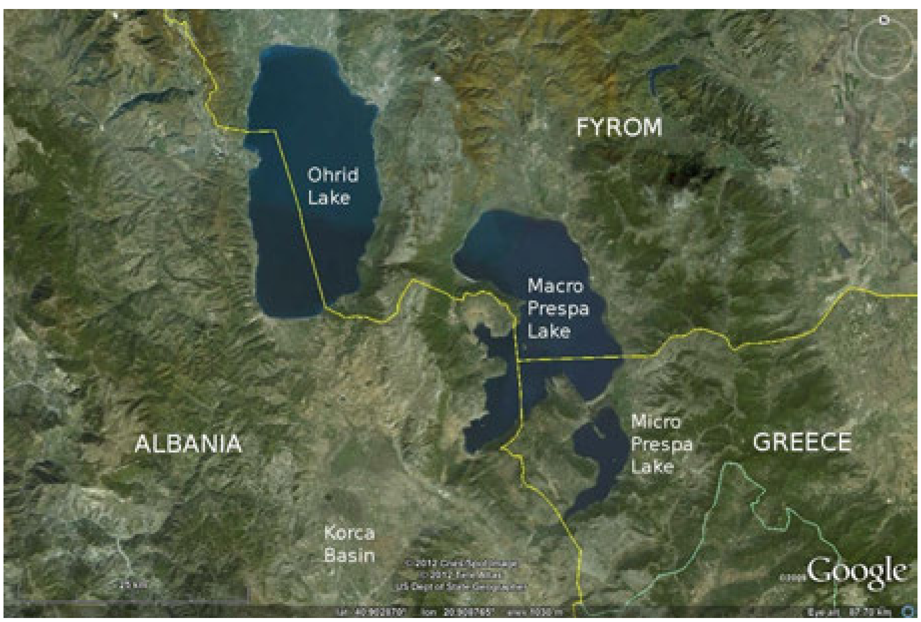


Fig. 1. Satellite image of Prespa-Ohrid lakes system.

Prespa Lake system is composed by Micro Prespa (surface 43 km2) and Macro Prespa (surface 276 km2) (Bornovas, J. and Rondoyanis, Th. 1985, Gligorevich, L.J. 1988, Hydrogeological Map of Albania, 1984, Pano, N. et al, 1989) This system has a catchment area of 1 363 km2. It is located on 850 meters above the sea level. Macro Prespa is a three-national lake, lying in the territories of FYROM (68%), Greece (14%) and Albania (18%). Its maximal depth is 55 m. Micro Prespa is a two-national lake, lying in the territories of Albania

(12.1%) and Greece (87.9%) (Fig. 2, Photo 1). Its maximal depth is 8 m.

In Albanian Prespa territory some villages are located on the lakeshores. Among these villages is Treni, well known of its prehistoric age origin, in the southwestern lakeshore of Micro Prespa. The population was 6755 inhabitants, in 1997.

Prespa present hilly-mountainous area. Start from the 850 m hypsometric level at Devolli plant, toward the Prespa Lakes, hilly area has a maximal hypsometric level up to 962 meters. At easterdirection are located the mountains. The mountains around Micro Prespa have an altitude up to 1456.7 m. and those of Macro Prespa have a hypsometric level up to 2035.4 m. Macro and Micro Prespa Lake catchments, lie on a mountains territory. Great changes of the mountain highs in a short horizontal distance are area feature. Dominant values of vertical cutting is on average level 100-300 m/km, while in the mountain areas this parameter has the values up to 800 m/km (Meçaj, N 1997).

Limestone landscape is typically karstic, rugged microrelief, karstic channels, fosses, and caves. Prespa Lake system represents a fascinating originality of its nature in Europe. The surrounding environment is characterized by a picturesque nature, particulat climate high biodiversity and, not accidentally, the lake is called the Balkan Pearl.

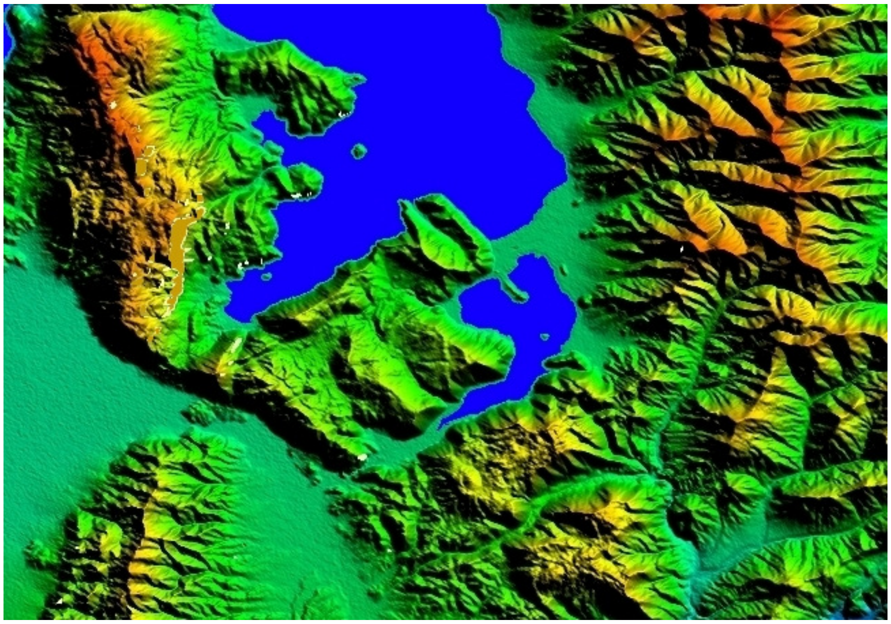


Fig. 2. Top – Satellite image of Micro Prespa Lake. Bottom – its Digital Terrain Model based in SRTM

3. Integrated study methodology

Environmental impact and ecosystem destructions of Micro Prespa Lake have been studying by a multidisciplinary complex methods: remote sensing analysis, hydrographical and limniological studies, hydrogeological, geological, and in particular neotectonics surveys, biological, and environmental investigations. Special attention was being paid for the analysis of the uncontrolled human activity in Prespa ecosystems.

Particular attention was given to estimation of the multi annual hydrological parameters of lakes and atmospheric conditions, solid sediment transport from Devolli river at Micro Prespa Lake, as well as chemical contamination of river and lake water by chemicals used in agriculture. Have been carry out the investigation of karstic phenomenon and circulation of groundwater through karstic space.

4. Limniology and hydrography of Micro Prespa Lake

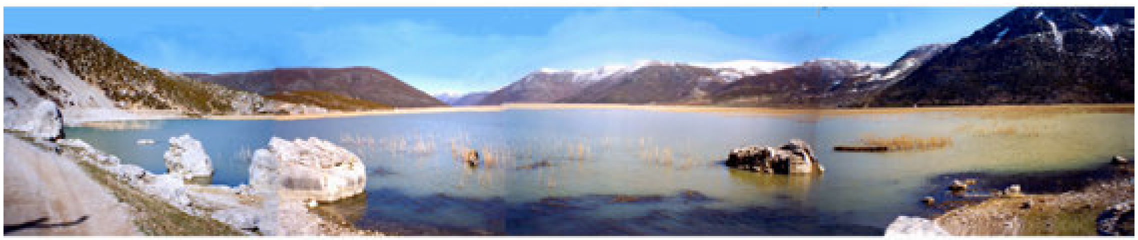
Korça and Pogradeci basins are characterized by minimal annual precipitation 722 mm and 765 mm respectively and maximal 1200 and 1000 mm. The annual average precipitation in the Dry Mountain (Mali Thate) is 900 mm (Chavkalovski, J 1996, Pano, N. et al 1997, Pano, N. and Frashëri, A. 1999, 2000) (Fig. 3a). Efficacious infiltration in this mountain is 455 mm, while evotranspiration is 426 mm. Water karstic volume of Dry Mountain is 5.2 m3/sec or 165.2x106 m3/year.

In this region, the Micro Prespa-Macro Prespa system represents the largest and the most important limnological object, not only for its great water capacity, but also for its great and special ecological values.

Prespa Lakes are among the most important ones in the Albanian hydrography. They lie in a NW-SE direction and have distinct characteristic. They are mountainous and relatively deep lakes (Fig. 2, Photo 1a, b, c). Micro Prespa length in Albanian territory is 5.75 km. Its minimal width is 125 m in Gryka Ujkut, in SW edge, its maximal width is up to 1500 m, between Shuec and Buzë Liqeni villages.

a)

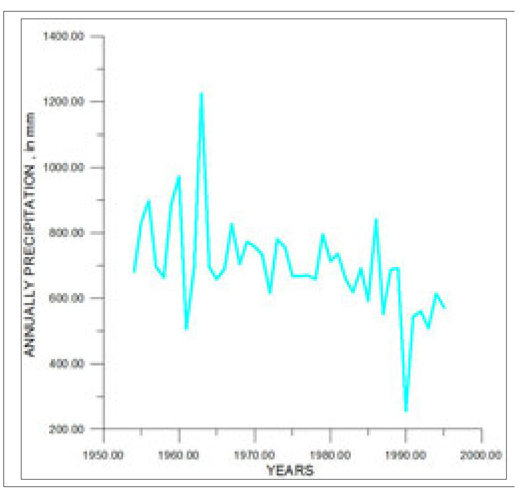
b)



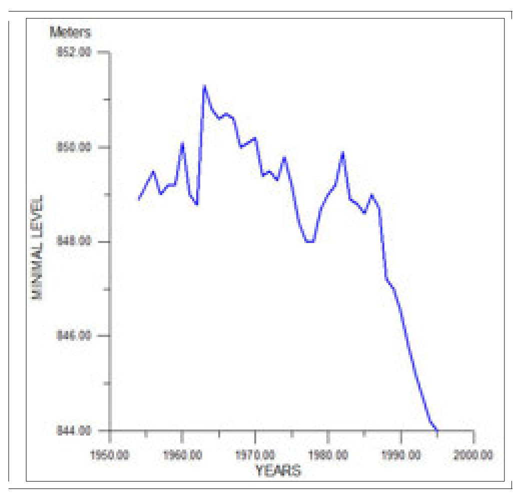
c)

Photo 1. Prespa Lakes views: a) Macro Prespa; b) and c) Micro Prespa views, 2006

There was only one lake in Prespa at the very beginning. It was divided in two parts by thousand years sediment of Saint German (St. German) river, that flows from Vabies mountain in Greece. Actually these two lakes are divided by a narrow piece of land of 3 km long by 1.2 km wide. The Micro Prespa and Macro Prespa lakes had the same water level in the past and were connected by a channel and subterranean karstic aquifers. Micro Prespa water flows in to Macro Prespa Lake through this channel (Fig. 2, Photo 2). A dramatic lowering of the water level occurred in Macro Prespa recently (Pano, N. et al 1989, Pano, N. and Frashëri, A. 2000, Chavkalovski, J. 1996) (Fig. 3b).



a)



b)

Fig. 3. Average annual precipitation in Pretori village, and average annual minimal water level (b), Makedonia (After data of Chavkalovski, I., 1997).

The lake was losing about 150x103 m3 each year. Today the two lakes have marked different water level. Micro Prespa Lake has a level at +850 m, while the Macro Prespa Lake

actually has a level at +846 m. There was a lowering of the water level of 7 meters in Macro Prespa Lake between 1987-1990. This means a water reduction of 900 million cubic meters of the water level .

Photo 2. The discharge of Micro Prespa Lake water in to Macro Prespa Lake, through the channel in Greek side, 2000 y.

Photo 3. Karstic activity, Macro Prespa Lake, 2006 y.

Macro Prespa water is very clear up to 20 m depth and it is light blue. During the summer the water temperature is up to 24oC and during the winter it goes up to 0.4oC. Some torrent flows in the eastern part of Macro Prespa and there have not any surface emissary. Intensive water discharges through subterranean ways mainly in Ohrid Lake, that is 145 m lower and in some karstic springs is Devolli plain. Macro Prespa water discharge into karstic limestone of Dry Mountain is very obvious near Gollomboç village (Photo 3, 4). Micro Prespa water was very clear too. Stones in its lake floor looked like beautiful mosaic. At the end of 20 century, water is completely turbid (Photo 5).

Photo 4. Point of the disappearing Macro Prespa water, which migrated to Ohrid Lake (from Google Earth).

Photo 5. Troubles waters in Micro Prespa Lake, 2000 y.

Ohrid is a two national lake lying in the territories of FYROM (70 %) and Albania (30%). It is a tectonic lake, formed during the Upper Miocene. It belongs to the oldest lakes group in the world, having the epithet " Natural Monument of Europe". UNESCO has registered the Ohrid Lake as "Natural and Cultural Inheritance of the World" since 1979. It water level is 695 m and the average depth 145 m. The maximal depth is 295 m, making it one of the deepest lakes in the Europe. Water temperature profil is presented in Fig. 4.

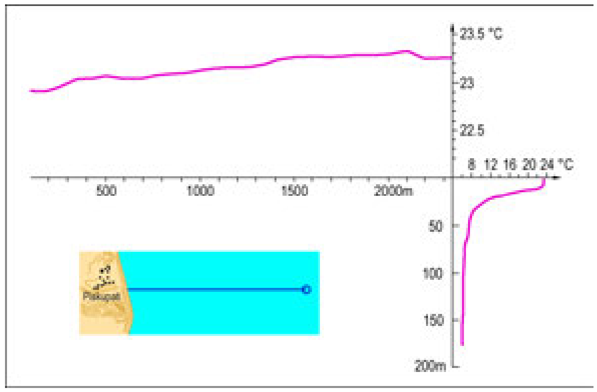


Fig. 4. Water temperature of Ohrid lake.

The Dry Mountain (Mali Thate) in Albanian territory and Galicica Mountain in Macedonian territory separate the Prespa Lake System and the Ohrid Lake. According to the isotopic hydrogeological studies it results that it is the same content of the 18O isotope of the oxygen and deuterium in the Ohrid and Prespa Lakes, and Tushemishti and Saint Naum springs (Eftimi, R. and Zoto, J 1997). It is assumed that all Ohrid Lake springs have a initiate from the Macro Prespa Lake, through the subterranean connected ways, which has a higher water level about 151 m. The springs which emerge in the Saint Naum lakeshore, in the Ohrid City in Macedonia, and in Drilon, Tushemisht etc. in Albanian territory, or those at the bottom of the Ohrid Lake, have a general yield of 12-15 m3/sek (Pano, N. et al 1989). This underground hydraulic connection makes it possible that Micro Prespa-Macro Prespa-Ohrid Lake system stands out in Europe for the fascinating originality of its nature.

5.Underground waters resources

Prespa district is rich in subterranean water resources which are linked with the existence of the two Prespa lakes, masive karstified limestone of Dry Mountain and the precipitation water infiltration in to karstified limestone (Hydrogeological Map of Albania 1984, Pano, N. et al. 1989). According to isotopic □18O (in %o) hydrogeological studies it is concludet that the average height of the precipitation infiltrating into Dry Mountain, is 1130 m (Efthimi, R. and Zoto, J. 1997).

In the western slope of Dry Mountain, from Progri village area to Tushemishti, there is a series of carstic springs. Their yield are determined by very developed underground karstic conections of the water circulation. Three springs, Gollobordë-Mançurishtë-Progër have bigger yield, about 500-600 l/sec. Springs or springs groups of a yield of about 1 to 100 l/sec lie at a distance of 2 km from each other. Strong springs of Tushemishti with a yield about 2 500 l/sec are northward, it Ohrid lakeshore.

But, alluvium which have sedimented in Micro Prespa lase floor has closed the underground water flow conections of some springs that are situated under the lake level (Pano,N. and Frashëri, A. 1999,2000). Recent studies have shown that the yield of some springs is reduced very much.

There are artesian water basins in Devolli and Korça plains. The Quaternary gravel depozits of old river terraces, covered by clay's layers, represented their water horizon.

6. Review on area geology

Prespa Lakes are located in the piedmont carbonate structure of Dry Mountain (Geological Map of Albania, 2002, Tectonic Map of Albania 1986, Pano, N. and Frashëri, A.

1999,2000). This carbonate structure presents a horst of Upper Triassic and Lower Jurassic age limestone (Fig. 5). Tectonic development during the geological periods was intensive on Triassic-Jurassic limestone. Upper Cretaceous limestone and middle Eocene flysch are lied in some sectors of the region. In the northwest of Macro Prespa Lake Pliocene clay and sandstone deposits are settled. Placers deposits, clay, argillite, clayed sand, sand, gravel, cobbles, broken stone of recent Quaternary are located over the Pliocene clay-sandstone and Eocene flysh lakeshores. Proluvial deposits are observed in some sectors. Ultrabasic rock individualization interrupts the Albanian side of Micro Prespa Lake. Ultrabasic rocks have a tectonic contact with limestone.

A Pliocene terrigene continental deposit shown that was deposited in the inter-mountain lakes and in the deltas of the rivers, which was flowed in these lakes. This fact demonstrated that under the neotectonics development, following contrast relations of the uplifts and plunges has been created the depression where are sediments the deposits (Fig. 5) (Aliaj, Sh. et al 1995, Pano, N and Frashëri, A. 2000, Hyseni, A. et al 1999. These lakes started to form during the Pliocene about 5.5 million years ago and were completely formed in Holocen period. Karstic activity was developed at the same time (Photo 3). So both, tectonic and karst development have been created the conditions in formation of the Macro and Micro Prespa lakes.

There was intensive erosion in all Prespa area rocks so a great quantity of alluvial sediments is carried and deposited to the bottom of these lakes.

Area geological settings is the main factor that conditioned lakeshore stability of the Prespa lakes. High and abrupt lakeshores are located at limestone's sectors (Fig. 5, 6). Abrupt lakeshores are located generally in the southwestern edge of Micro Prespa Lake. These shores are from 10 to 50 m high. Spilea rocks stands in the north side of the Wolf's Gorge (Gryka e Ujkut). They begin at the lakeshores and go up to 1150 meters. There some precipices are found, with a height from 10 up to 50 meters. Relatively un-stable are lakeshores in the Quaternary, Pliocene clay-sand's deposits or Eocene flysch sectors, in the particularly in the slope breccias sectors. In other shores sectors, the slopes are some meters away from the lakeshores. There is a gravel belt between them. In the lakeshores of both Prespa lakes have flow's cones of the mountain's streams, which are dry during the summer.

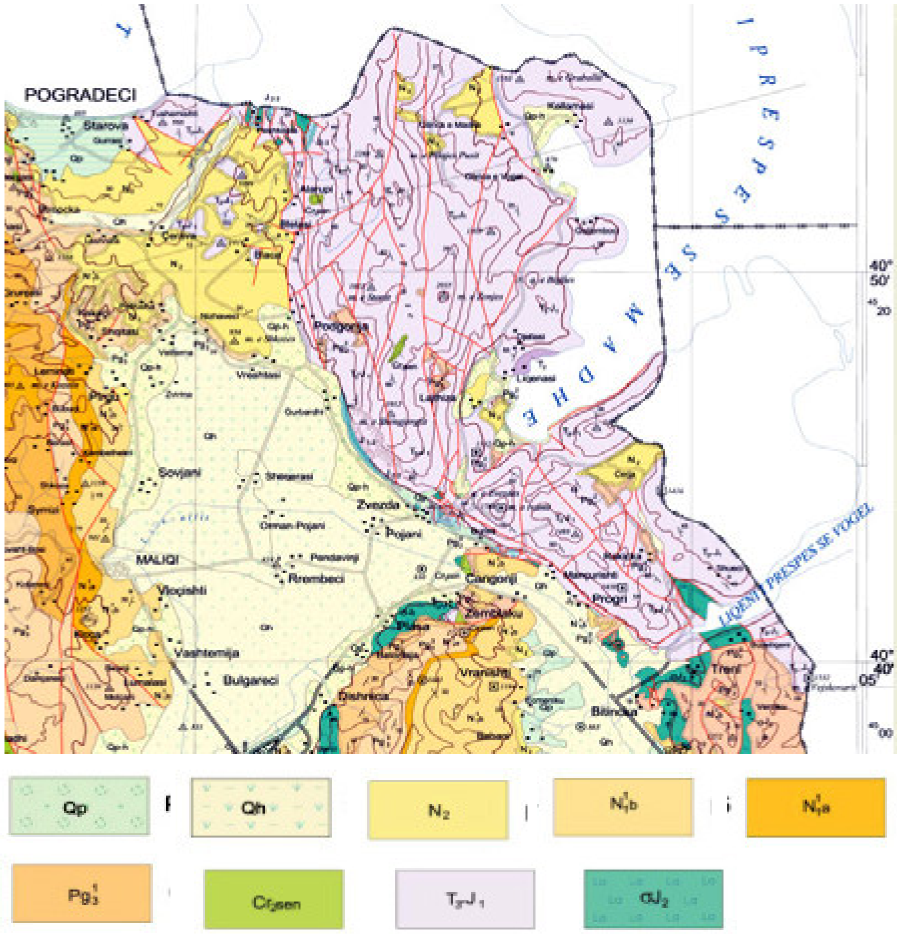


Fig.. 5. Geological Map, Prespa lakes-Ohrid Lake area. (Geological Map of Albania, at scale 1:200.000, 2002). 1. Holocen- alluvion, proluvion, lacustrine, aleurolite, sand, gravel; 2- Holocen- swap deposits, clay, sand peat; 3- Pliocene- clay, sanstone, gravelite, conglomerate; 4- Burdigalian- clay marl, siltstone, limestone, limestone; 5- Aquitanian- sandstone, siltstone, conglomerate; 6- Lower Olygocene- muddy and siltstone flysch, limestone; 7- Upper Cretaceous, Senomian- limestone, conglomeratic limestone; 8- Upper Triassic-Lower Jurasic- Limestone, dolomite; 9- Amphobolitic peridotite.

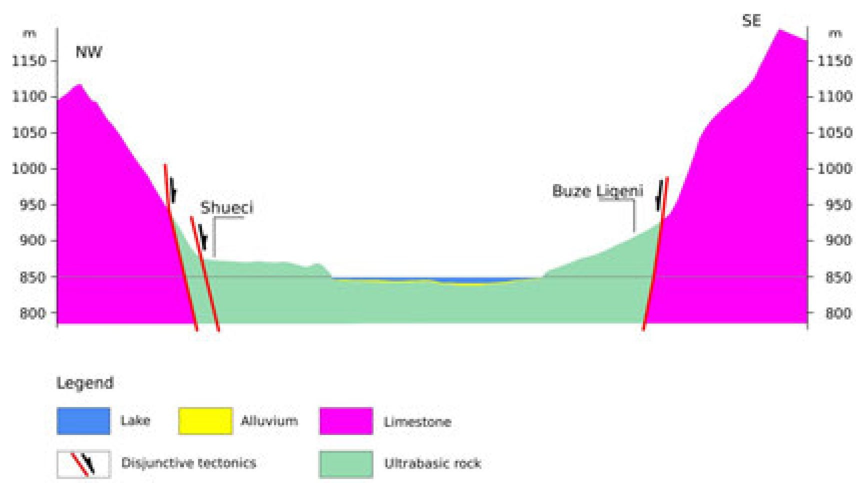


Fig. 6. Geological Profile through Micro Prespa Lake

The geological settings of the region has created the condition to find some minerals in Prespa area, in particularly industrial materials (construction's materials). There are quartzose sand and clay. Limestone and ultrabasic rocks represented very high quality constructive materials.

7. Biodiversity and present legal protection status

The biodiversity of Micro Prespa Lake is very rich (Bega F. 2000, Bimo T. 2000, Pano, N. et al 1997, Pepo E. 2000, Qoshja, Zh. 1979, Rakaj N. 2000, Shumka S. 2000).

The Prespa area envrironment is aride. The Flora – vegetation and forests with 71 sorts of trees, shrubbu trees, and the aquatic bed plants extend in some sectors:

- The aquatic bed plants: Caratophyllum sp., Myriophyllum sp., Lemna Minor, Trapa Natans, Nymphaea Alban, etc.
- The trees: Salix sp, Querqus Cerris, Querqus Pubescens, Querqus Petrea, Fagus Silvatica, Oatria Caprinifolia, Fraxinus Ornus, Carpinus Betulus, Acer Pseudoplantanus, Pinus Nigra, Abies, Ingland Regia, Castanea Sativa, Corulys, Juniperus, etc. Oak forests in Maja Zonjës, Maja Kallogjerit and Faqes së Osojës in Makro Prespa area and Koria e Trenit in Micro Prespa area make this region very beautiful.
- The Emergents:Carex sp., Trifolium sp., Phragmites australis, Tupha sp., Scirpus sp., etc.

The fauna of the Prespa Lakes distinguished by:

- Rare fish Rutilus prespensis,Chordrostoma prespensis, Barbus prespensis, Albumus belvica, Albumoides binpunctatus orhiadanus, Cobitis meridionalis, Cyprinus carpio, Salmotrutta peristericus, etc.
- Birds: Pelecanus criptus Bruch (Photo 6 a,b), Pelecanus onoctotalus, Pholacrocorax pygmeus, Ardea purpurea, Plegadis falcinellus, Egretta alba, Platalea leucorodian Anser anser are representatives of the birds.
- Mammals are habitants of the Prespa area, as Rhinolophus ferrumequinum, Pipistrellus nathussi, Glis glis, Canis lupus, C. aureus, Lutra lutra, Felix silvestris, Meles meles, Ursus arctos, etc
- The Polygonetum amphibii are very sparseness associacion in the Prespa lakes. In particularly the Potameto-Najadetum H. findet in the Macro Prespa Lake.
- The pelagic zooplankton community of Micropresра Lake consists of 43 species. The main representatives of the zooplankton are composed by: Protozoa-1 specie, Ritatoria-16 species, Cladocera-16 species, Copepoda-9 species and Mollusca-1 specie.

Photo 6 a, b. View of Pelecanus Criptus Bruch.

Prespa's Lake catchment has unique natural values, particularly ecological value. It has great international values. Not accidentally the lake is called the Balkan Pearl. Since 1957 it was

become as National Park, Wetland of International Importance in accordance with Ramsar Convention, Special Protection Area (79/409/EEC), and Important Bird Area (ICBP-IWRB).

8. Historical wealth of Prespa

Baing very beautiful and having favorable natural conditions, Devolli and Pogradeci areas were the living place of Enkeley Ilirian tribes in 1500-1400 BC (History of Albania 1959, Samsuri V. 2000). In Micro Prespa lakeshore, in its south-west edge, there is a prehistorical living place, Treni cave (Photo 7). The first living traces in this cave belong to Neolithic Age (Ancien Neolit). The others cultural layers belong to Bronze Age (ancien and late) and the Iron Age as well. Prehistoric drawings found on Spilies rocks, in the northern lakeshore of Micro Prespa Lake are of a great value (Photo 8). At the same time the eremeticus cherchs built in Prespa area rocks is of a great historical value.

In 851-1018 new towns appeared in this area. The center of it was Devolli town. During the last years of the 10th century Prespa and later Ohrid become important centers of the Bulgarian empire of that time. It is characteristic that all the orthodox churches of the XIII-XIV centuries were built according to the bisant style. One of the fourth cherches that could servire is that of St Mary'' in Grad Mountain Island in Macro Prespa lake. It was build during the 14th century and its famous for its wall pictures of great artistic values.

Photo 7. Prehistoric Treni cave at Micro Prespa lakeshores.

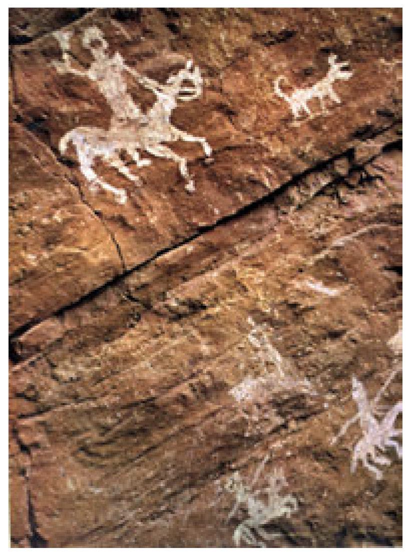


Photo 8. Prehistoric ancient designs at the Spilea rocks, on Micro Prespa lakeshore (after Andon Grazhdani 2000).

9. Anthropogenous impact

Unfortunately, anthropogenous activity has greatly damaged the ecological values of Prespa Lakes system for a long time, in particular in the Albanian part of Micro Prespa Lake, which have caused the lake biological equilibrium and biodiversity destruction (Pano, N. and Frashëri, A: 2000):

- The construction of the hydrotechnical works (Fig. 7):
  - Network channel (1976), for the irrigation of Devolli and Korça plants,
  - Supply of Micro Prespa lake with Devolli River water (Photo 9),
  - Opening of new agricultural land against agrotechnical criteria, and
  - Discharge of polluted urban and industrial water into this system etc.
- Habitat loss and deterioration of over the last five years are the major factors causing

serious threat to plants and animal species.

- Uncontrolled timber harvesting and overgrazing have resulted in degradation deforestration of the forest resources and serious erosion.
- Uncontrolled fishing and hunting have caused great damage to a large number of fish species and games.

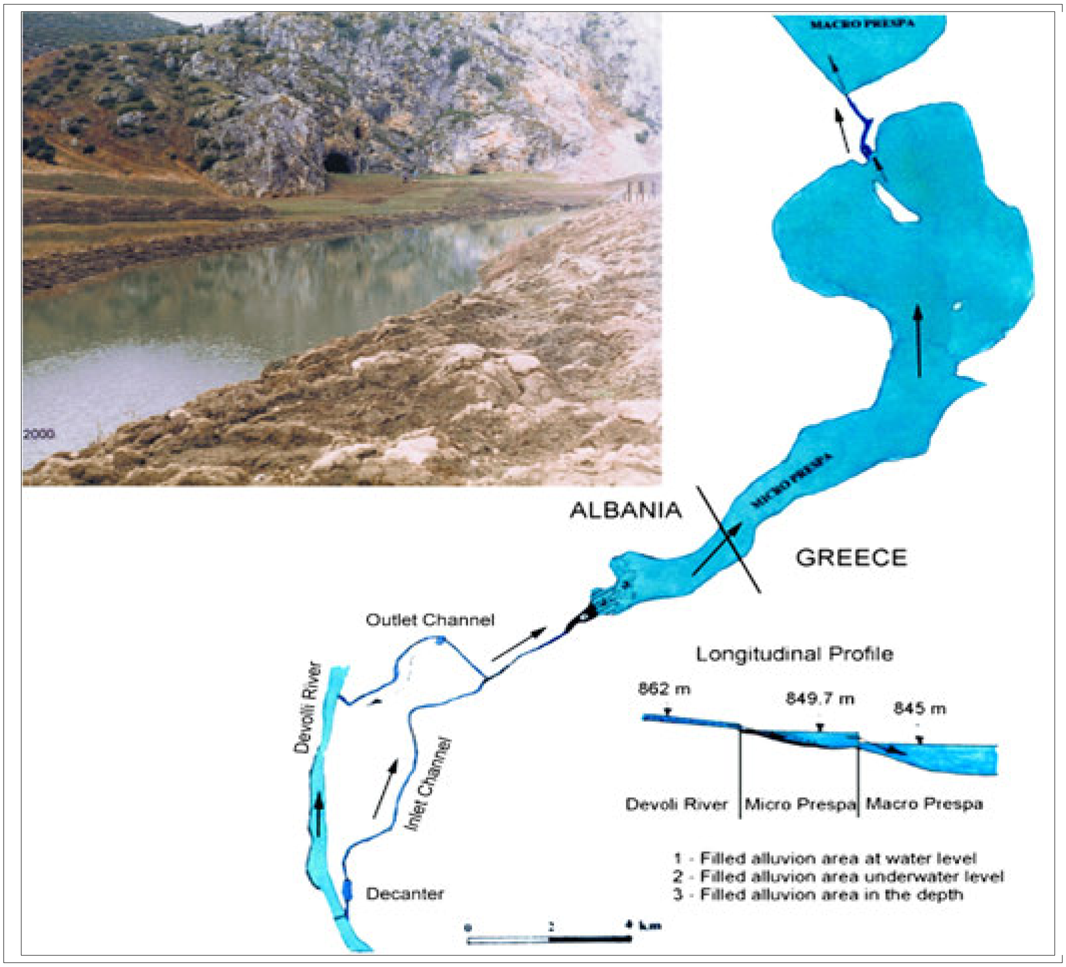


Fig. 7 Water Supply and Irrigation System Sketch from Devolli River to the Micro Prespa Lake and water flow to the Macro Prespa Lake. Top – Left: photo of the channel that supplied Micro Prespa Lake with Devolli River water.

9.1 . The influence of the hydrotechnical constructions on destruction and ecological stress of the Micro Prespa Lake.

A channel of a water capacity Q=10 m3/sec to supply Micro Prespa Lake with Devolli River water during the winter was constructed in 1976 (Fig. 7). 30-70 million cubic meters water a year was discharged into Micro Prespa Lake through this channel. According to the project, the maximal water hyplometric level in the lake was 852.2 m at end of the supply period. During the summer, the lake water has been used for the irigation of Korça and Devilli plains, with a surface of 22 500 ha. The maximal quote of exploitation, by the project has been 850.2 m.and can be used 90 milion cubic meters water.

The waters of Devolli River, which is one of the most turbid rivers of the Balkan Peninsula. Waters of Devolli River have a mean mineralization M = 483 mg/l and a hardness 12 German degree. Granules with a diameter less than 0.02 mm have predominated in this

sediment. Granules with a diameter less than 0.002 mm are up to 14% of this sediment mass. According to the American Classification ASTM, this sediment is classified as Lean Clay CL. According to their plasticity index Ip=13.5, and to the upper and lower limit of the plasticity, respectively Wl= 42.2% and Wp=28.7 %, illite and montmorillonite represents this clay material. Great amount of Devolli River waters flowing in to Micro Prespa Lake during the winter. A considerable amount of solid matter enter in to the Prespa Lake and were decented in the lake. Under existing conditions, Micro Prespa Lake plays the role of an authentic gigantic decanter (Photo 10a, b, c).

To avoid alluvium a decanter, have been constructed, which in reality doesn’t work. Studies have shown that Devolli River water flows undecanted into Micro Prespa Lake, depositing about 1.2 million cubic metters of alluvium, which has resulted in lowering of the water volume, lake surface and drastically damaging the lake ecological values. Being free of alluvium, but not by the chemicals, the water flows into Macro Prespa lake, converting into international waters.

In these condition Devolli River-Micro Prespa Lake irrigation system ist’n scientifically based not only on environmental engineering but also but also on hydroeconomial and international rights laws. It also does not work according to the projected parameters and does not correspond to the agricultural needs. Water quantities taken from Micro Prespa in summer, especially during the last years, have been les that 10% of the volume of the water inserted into the lake. So, in 1997, only 2.3 million cubic meters was taken away instead of 90 million cubic meters projected to be taken. In 1998 only 5 million cubic meters and in 1999 also anly 5 million cubic meters or 0.4 m3/sec from 10 m3/sec according to the project. This happened because Micro Prespa Lake communicate with Macro Prespa Lake (Fig. 7, Photo 1c). In these conditions turbid water of Devolli River upon flowing in Micro Prespa Lake decant in it, ruining it and, being free of alluvium, flow in Macro Prespa Lake.

9.2. Damages of the biodiversity

Micro Prespa Lake has great problems of eutrophism (Photo 1c, 11, 12). Eutrophication processes are promoted by enrichment in nutrients. The direct consequence of such addition is represented by a change in biodiversity (Bega F. 2000, Bimo T. 2000, Pano, N. et al 1997, Pano, N. and Frashëri, A 2000, Pepo E. 2000, Qoshja, Zh. 1979, Rakaj N. 2000, Shumka S. 2000).

Another negative aspect is the penetrating of a considerable quantity of toxic remains and absorbed coal organic material by the drainage of Devolli farm grounds and by geological section outcrop. The lake water content nitrite, nitrate, ammoniac, phosphate, carbonate, and organic material. Chemical change of the water has been observed up to a distance of some hundred meters, from the southwester edge of lakeshore to inside of the lake (Kanani K. 2000). This changes the lake water features and degrades their habitats.

Habitat loss and deterioration of over the last five years are the major factors causing serious threat to plants and animal species. In particular, this phenomenon obviously influences a part of the aquatic flora and fauna in the lake.

9.3. Threaten flora

- The aquatic bed plants: Nymphaea Alban in paeticularly, Caratophyllum sp., Myriophyllum sp., Lemna Minor, Trapa Natans, Leucojo-Fraxinetum Angustifobiliae, Potameto-Wallisnerietum, Nymphoidetum Peltatae etj.
- The trees: Carpinus Betulus, Acer Pseudoplantanus, Corulys, etc.

9.4. Threaten fauna

- The fishes: Leuciscus Illyricus; Salmotrutta Peristeris; Barbus Prespensis
- The zooplankton: Eutrophication processes have changed also in zooplancton composition of Micro Prespa Lake.

a)

b)

c)

Photo 10. General view of the damages of ecosystem at Prespa Lake shore,

(a) 2000 y., (b)(c) 2006 y.

9.5. Underground water resoures and springs

Lacustrine alluvium has coated all shallows of Micro Prespa lakeside and has blocked its underground water resources. As a result water balance of Micro Prespa Lake is ruined and drinkable water springs yield is diminished. There are springs such as Ventrok that had a great discharge of 13.8 l/sec before the lake was stuffed with sediment deposition that is drying up.

Environmental Evolution of Micro Prespa Lake Using Landsat Images

The analysis is based on Landsat images from years 1972 (1973 for the NIr band), 1987, 2002 and 2010. Three methods were used for the processing of images:

a) Natural color combination Blue-Green-Red for each year, enhancing the colors in water surfaces in order to make visible water turbulences. Enhancement of colors was done keeping as reference the Ohrid Lake, which water showed no signs of turbulences.

b) Combination in false colors of NIr bands in two ways: 1973~Blue, 1987~Green, 2002~Red and 1987~Blue, 2002~Green, 2010~Red. Such combinations were used to identify variations of lakes shores [Frasheri Cico Fundo, 2010]

c) Combination in false colors of NDVI in two ways: 1973~Blue, 1987~Green, 2002~Red and 1987~Blue, 2002~Green, 2010~Red. Such combinations were used to identify variations of vegetation lakes shores [Frasheri Cico Fundo, 2010]

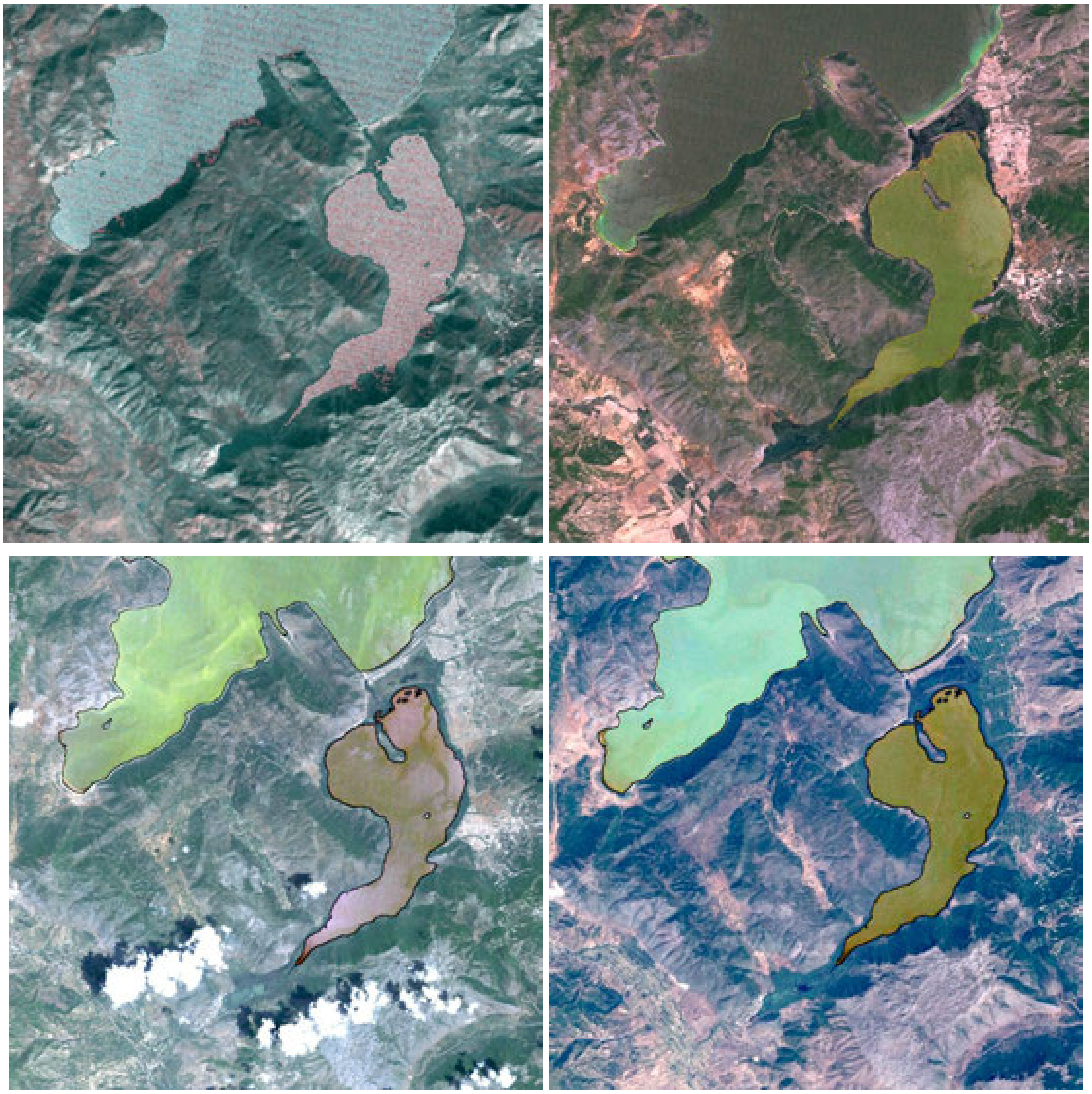


Fig. Aaa – Natural enhanced colors of Macro and Micro Prespa Lakes (top left ~ 1972, top right ~ 1987, bottom left ~ 2002, bottom right ~ 2010)

In 1972 there are no significant turbulences in both Macro Prespa and Micro Prespa. Water of Micro Prespa looked more “reddish” proobably because of being more shallow. Instead, in 1987 there are first signs of turbulences in Micro Prespa, and first signs of turbulences near shores in Macro Prespa. Situation resulted dramatic in 2002, while showed a little improvement in 2010 as result of interruption of water flow from River Devolli in Southwestern corner of Micro Prespa (colors of this corner are not enhanced).

A view of Southwestern corner of Micro Prespa Lake is visible in Google Earth.

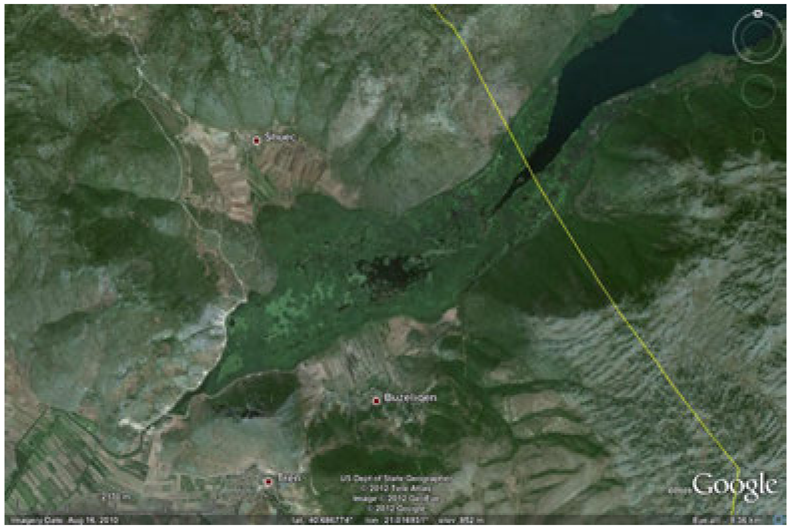


Fig. Bbb – Google Earth image of Southwestern corner of Micro Prespa Lake. Villages of Shueci and Buze Liqeni are shown as repers for the geological profile of the Lake

It is clearly visible that almost the whole corner is filled with vegetation (mostly reeds), except a small area at its center. In the bottom-left corner of the image there is visible the channel used to flow Devolli River waters into the Lake during winter time.

The variation of lakes shores was done comparing NIr images by combining them using false colors. Permanent water areas appear in black, permanent ground areas in gray or nuamces having all three RGB base colors, while areas where the shore line has moved appear in specific colors with only one or two components of base colors.

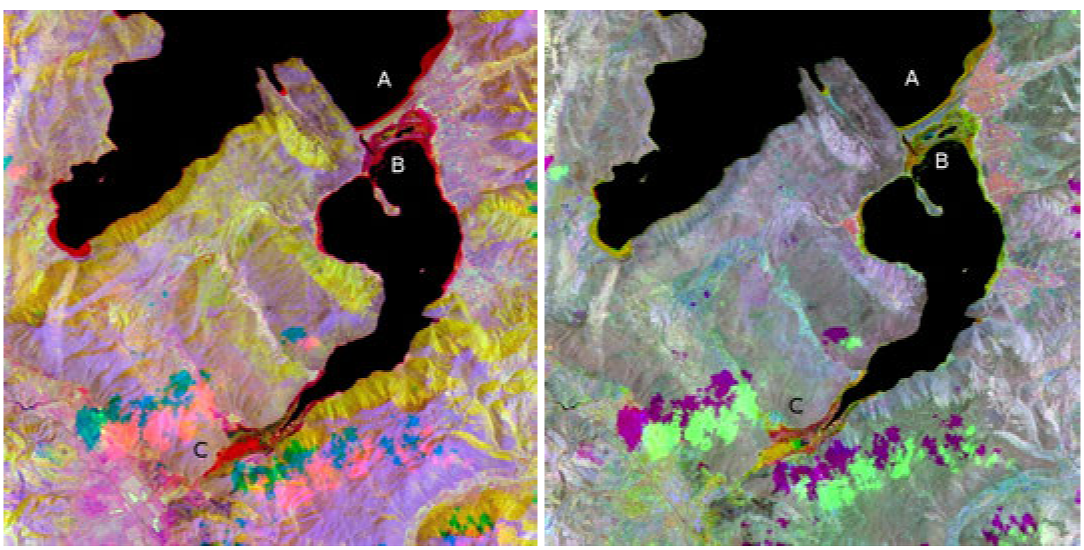


Fig Ccc – Combination of NIr bands (left: 1973-1987-2002, right 1987-2002-2010)

In the combination of 1973(blue) – 1987(green) – 2002(red) part of Macro Prespa Lake shore ("A"), the Northern shore ("B") and the Southwestern corner of Micro Prespa ("C") are in clear red color, indicating that during the period 1987–2002 there is a loss of water surface. In Macro Prespa it was result of decrease of water level, while in Micro Prespa it was result of sedimentation and increase of reeds. In the combination of 1987(blue) – 2002(green) – 2010(red) the same areas A and B show lack of red component, indication that during 2002–2010 there was no change in the shore line. Instead in the area A there are reddish spots due to development of reeds while in its center the green spot indicates that the

area filled with reeds in 2002 resulted improved as clear water in 2010.

The variations in time of NDVI are presented with false colors in the figure:

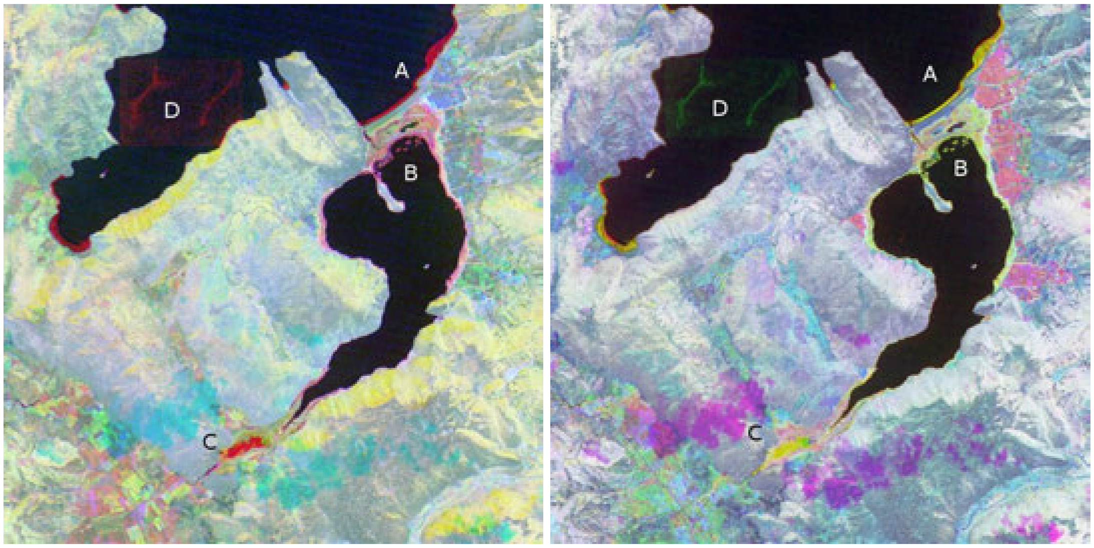


Fig Ddd – Combination of NDVI (left: 1973-1987-2002, right 1987-2002-2010)

The same phenomena are visible in false color combinations of NDVI for the two periods 1972(blue) – 1987(green) – 2002(red) and 1987(blue) – 2002(green) – 2010(red). The environmental situation in both Macro and Micro Prespa Lakes is deteriorated during the period 1987 – 2002 and has a slight improvement during 2002 – 2010, result of interruption of water loss in Macro Prespa and of Devolli River water flow in Micro Prespa. The area indicated by “D” shows strips of algae developed in Macro Prespa waters in 2002.

11. Otherwise of Albanian territory in the Prespa area – as a conclusion

The above factors have helped sediment deposition of about 1.2□ million cubic meters into Minor Prespa Lake, diminishing the water volume and the surface of this lake. It is the otherwise of the Albanian territory.

The lack of the respective action plans and platforms for scientific and economic cooperation based on International Legal Acts, has in turn damaged the creation of the necessary space for the complex and integral use of the hydrological resources of this lake system for hydro-economic purposes, conserving ecological values.

It is this pearl that Albania is losing as a result of uncontrolled human activity. Albania will not have any part in Micro Prespa Lake after some years as a results of this great deterioration which is spreading all over the lake. This destruction of the Albanian side of Micro Prespa Lake step by step will extend in all water volume of the lake. Being Transborder Lake, their destruction will bring problems in the relation between both countries.

Being scientists, we made an appeal to local community and government, state government and scientists of different fields to take urgent measures to interrupt the further damage of Micro Prespa lake and the unlawful change to Albanian territory.

Let us save this pearl, regenerating it, improving the life the local inhabitants and transforming the district into a wonderful tourist place.

a)

b)

Photo 11. Eutrophication of the Micro Prespa Lake water, 2000 y.

a) b)

Photo 12a, b. Eutrophication of the Micro Prespa Lake water, 2006 y.

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JUBILEE CONFERENCE

"90 YEARS OF THE
ALBANIAN GEOLOGY"

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GEOPHYSICAL CONTRIBUTIONS DURING 90 YEARS OF ALBANIAN GEOLOGY, AND FACING OF THE TRANSITION CHALLENGE.

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Abstract

In the speech are presented the development of the geophysical exploration in Albania, contribute of the geophysics and facing the challenges during the transition period toward free market economy.

Albania is a rich country in mineral resources, chrome, copper, iron-nickel, coal, oil and gas etc. The exploration for these mineral deposits is carried out successfully by using a wide and complex range of geological, geophysical and geochemical methods. There are tens of oil and gas reservoirs, tens of copper, chromite, etc. deposits that have been discovered through geophysics contribution. Gravity, magnetic, geothermal and seismic zoning maps of different scales up to 1:200.000 and 1:500.000 are important part of regional studies on the recognition of geological setting of Albanides. Geophysical studies and research are conducted in Albania for more than 70 years. The first geophysical researches have been performed during thirty years, with gravity, and magnetic survey, vertical electrical soundings, by Italian companies in the years 30-40. Geophysical research in large polygons for oil and gas reservoirs, and copper, chromite deposits explorations began systematically to 50 years period. Gradually, step by step, we have applied different geophysical methods. The successful Albanian geophysics in search for metallic deposits and oil and gas reservoirs have been published in many papers in national and international scientific press, and presented in the national and international meetings.

On shore and of shore oil and gas exploration have been performed using seismic reflection surveys, gravity mapping, and small volume of the vertical electrical soundings. Mining geophysics for copper, chromite, bauxites deposits exploration is developed through application of the gravity and magnetic mapping of different scales, induced polarization profiling and real-section surveys, electromagnetic profiling, resistivity profiling and vertical electrical soundings, self potential mapping. Radiometric and nuclear geophysics have been used for phosphorite research. Oil and gas, copper, chromite, phosphorite, coal wells have been studies using complex of the electrical, sonic, radioactive and nuclear well logging,

Important direction of Geophysics presents seismological studies in Albania. These studies have been developed to three areas: seismotectonics, seismology and seismologic engineering.

Last two decades represent the period of extension of the field of application of shallow engineering and environmental geophysical methods to solve the geotechnical tasks, hydrogeological research, the micro-zoning of main Albanian cities, the study and evaluation of geothermal energy, and environmental studies for impact evaluation and water pollution, etc.

Geophysical Branch in the Faculty of Geology and Mining, Polytechnic University of Tirana, during a half of century period from 1961 up to present have graduated 304 geophysicist engineers, and 48 doctors of sciences.

Albanian Geophysicists have established since 1989 Geophysical Society of Albania (GSA), which is part of the Albanian Association of Geoscientists and Engineers (AAGE). GSA is a member of the European Association of Geoscientists and Engineers (EAGE) and the Balkan Geophysical Society (BGS).

Key words: Albanian Geophysics, Mining Geophysics, Oil and Gas Geophysics, Engineer and Environmental Geophysics.

INTRODUCTION

Albania is rich with natural resources: oil, gas and solid minerals. Integrated geological-geophysical-geochemical prospecting have discovered and developed tens of solid mineral deposits, and oil and gas reservoirs in Albania.

In order to demonstrate the economic capacity of the Albanian Mining and Petroleum Industries, it is sufficient to indicate that only during 1984 there were extracted 1,007,000 tons of copper minerals and processed 12,600 tons of blister copper, as well as 960,000 tons chromites. The average income from the copper and chromium extracting industries was 120 million USD. About 20 million tons of copper minerals and 21 million tons of chromites have been extracted by the Albanian Mining Industry. Oil production reached a peak of 2.250.000 tons in 1973. Up until 1990s, there were extracted 49, 5 million tons of oil, about 12 million cubic meters of natural, and 47 million tons of coils. Unfortunately, during the transition period among 1990 to 2010, the volume of extraction by the mining and oil industry has steadily decreased. According to the official statistics, INSTAT, the mining production has decreased as following*:* 88.6 in 1994, 86.5 in 1995, 75.8 in 1996, 47.1 in 1997, 74.5 in 1998, 35.5 in 1999, 31.0 in 2000, and 27.0 in 2001.

Geological prospecting have evaluated the mineral resources, capable of extraction as 31 million tons of oil, 53 million tons of cooper minerals, 40 million tons of chromites, 220 million tons of Ferro nickel, 100 million tons of nickel, 700 million tons of coil. More than twice of the extracted copper and chromites ores are estimated by geological exploration and developing statement of the resources for the future.

The Bitumen from the Selenica mines in southern Albania has been extracted since the ancient times. Illyrian tribe of pirusts was well known for copper processing. An activist of the Albanian Renaissance, the philosopher Sami Frashëri, in his book "Albania, What It Was, What It Is, and What Will It Be (1899), wrote "…it is necessary to explore all metals all over Albania … In the capital of Albania, in addition to secondary schools must be a university, and an academy….. to develop in Albania the literature, history,…. and geology, etc.". Nearly half a century later, a politician Mehdi Frashëri in his book "The Albanian Problem" (1944) wrote: "... At near future, Albanian oil in Kuçovo as well as in Patos will form a source of national wealth and a key target for state revenues " and "… in Albania there have been explored some ores, which can also reasonably be used for developing the economy and industry of the country….". Procuring fuel, as in time of peace as well as in time of war has taken a great importance that plays a leading role role in foreign policy of states. For these reasons, fuel in majority of states have been the monopoly items. On the one hand to give sufficient revenues to state case, on the other side to have under control; for all of its cases, if the monopolization of the fuels in foreign hands is a suicide, that in case of need the state lacks main factor of each movement (p110).

In the 1920s and 1930s, oil was discovered in Kuçova, and it was processed, also copper was extracted in Rubik, and a little later started the extraction of chromium. The programs elaborated by our philosophers and statesmen were fully implemented after the World War II. The new state took particular attention to further developing the exploration, extraction and processing of the natural

resources, and it put those industries at the cornerstone of the socio-economic development of Albania. The development of those industries went hand in hand with the formation of a new cadre of young specialists, who were able and willing to explore and to extract the mineral wealth of the homeland, and to selflessly contribute to the development of the state and economy.

Geophysical studies and research are conducted in Albania for more than 70 years. First gravimetric and magnetic surveys and electrical soundings have been performed during thirty years by Italian company. Geophysical research in large polygons has started systematically from 1950 year for oil and gas,

gradually to apply different methods: Gravity survey, Vertical Electrical Soundings, and Well logging (1950), Seismic surveys (1952). From 1953 has started application of the Geoelectrical surveys for cooper exploration, magnetic surveys (1957) and gravity surveys (1958) for chromite exploration. Radiometric surveys (1959), and geothermal studies (1989). Offshore seismic and geoelectrical surveys in Albanian Adriatic Sea Shelf for oil and gas exploration have started from 1982. Geophysical research in fifty's years was performed by Soviet and German geophysicists. From 1952 he returned from overseas studies two first Albanian engineers. At that time was formed also the first geophysicist's technicians. After 1961, all geophysical surveys have been performed by Albanian geophysicists. For two years in the seventy's years, the Albanian geophysicists have worked together with the Chinese geophysicists. Today, after 60 years, there are 304 geophysicists, as well as dozens of physicists, electrical engineers, etc. that have working on geophysical surveys. Among them are 48 doctors of sciences, 7 professors, and 22 leading researchers and masters.

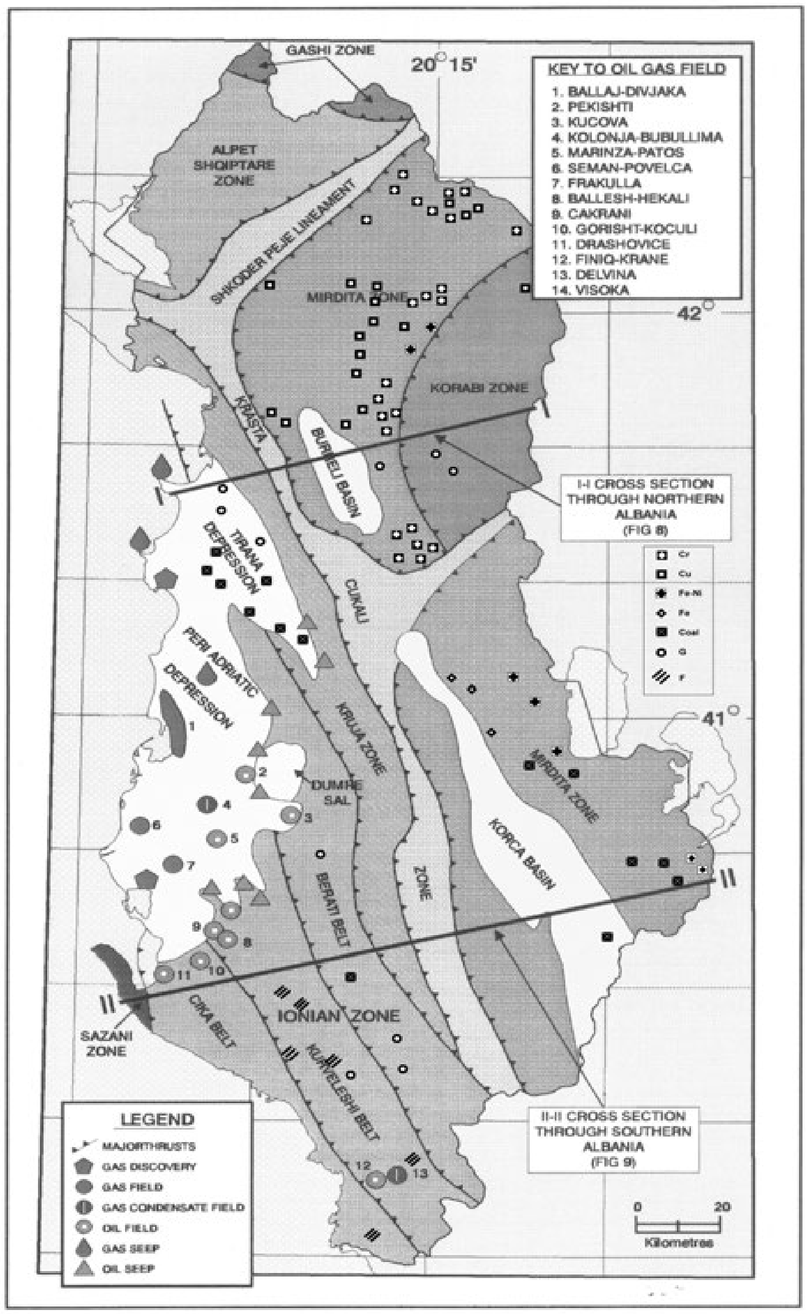

Fig. 1. Important oil and gas reservoirs and solid minerals deposits in Albania.

Albanian Geophysicists have established since 1989 Geophysical Society of Albania (GSA), which is part of the Albanian Association of Geoscientists and Engineers (AAGE). GSA is a member of the European Association of Geoscientists and Engineers (EAGE) and the Balkan Geophysical Society (BGS).

Geophysical studies in Albania, year by year have been developed as complex methods, such as technological level of the surveys and interpretation, and are raised up coordination with other geological and geochemical methods. The realization of the development of Geophysics at the beginning of the period 1972-1986 is sensitive behavior of equipment and modern technologies for seismic, gravity, geoelectric, magnetic surveys, radiometric studies and well logging.

Geophysical Exploration and studies have been performed in the framework of the three Geophysical Enterprises [Biçoku T., 2004, Frashëri A. et al. 2010].

1. Oil and Gas Seismic and Gravity Enterprise in Fieri City: 70 geophysicists enginees, four seismic teams, gravimetric one, a geoelectrical team, as well as marine expedition with seismic, geological and geoelectrical teams. Enterprise has realized about 2500 km/year of seismic profiling by multiple coverage.

2. Oil and Gas Well Logging Enterprise in Patosi City: 30 geophysicist's engineers, the electric, radioactive, sonic groups, gas logging, and perforator's groups, laboratory of physical properties of the rocks and interpretation group. Well logging groups carry integrated geophysical study of exploration deep wells for oil and gas with an annual volume of 80,000 linear meters of wells with a depth up to 6700 m, and tens of thousands linear meters of production wells.

3. Geophysical Enterprise of Tirana for mining geophysics: 106 geophysicist's engineers. Geoelectrical Teams have realized about 35-40 km^2/year mapping at the scale of 1:10 000, 1:5.000 and 1:2.000. Averagely the same area has covered also by the gravity and magnetic survey. In 2008, the restructuring of the Albanian Geological Service, the company was reformed: several specialists went to the Institute of Earth Sciences was established, some remained in the unit geophysical Albanian Geological Service.

Tab. 1 Application fields and geophysical methods applied in Albania

GEOPHYSICS	Methods	Application fields			
		Oil & gas	Mining	Engineering & Environmental	Regional
Applied	Seismic reflection	++		++	+
	Electrical	+	++	++	+
	Gravity	+	+	+	++
	Magnetic		+	+	++
	Well logging	++	+	+	+
	Radiometric		+	+	+
Seismology	Earthquakes	1. Seismological Surveys Network 2. Seismological zoning of Albania			
	Engineering	1. Seismic Micro zoning and seismic risk evaluation 2.Seismic monitoring of the hydropower plant dams			
Geothermic	1. Geothermal studies 2. Geothermal energy platform and use scenarios.				

++ *Principal method*

In Geological & Geodesic Enterprise of the Ministry of Construction and in the Hidrogeological Enterprise of Tirana have two specialized geophysical expeditions for engineering geophysics (1983) and water research (1980).

Important direction of Geophysics in Albania presents the seismological studies, which have been conducted by the Institute of Seismology, Academy of Sciences. These studies pertain to three areas: seismotectonic, seismology and earthquake engineering. The first seismic station was established in 1968, at the Chair of Geophysics, Faculty of Geology and Mining. Seismological Institute was established in 1973 at the Academy of Sciences. Has been set-up the seismological network with 13 stations in Albania.

In 2008 the institute, was involved in the Institute of Earth Sciences in the Polytechnic University of Tirana

Teaching of Applied Geophysics case began in the Geological of Department of the Polytechnic Institute of Tirana (1955). The formation of geophysical engineers and their post graduate training since 1961 have been performed in the Geophysical Branch, Chair of Geophysics Faculty of Geology and Mining, Polytechnic University of Tirana. The period of study was five years for engineers [Frashëri A. et al, 2008].

Geophysicists of all generations have given outstanding contribution to the discovery of ten oil and gas reservoirs, eleven copper deposits, and many other solid minerals. They have performed geophysical regional studies of the Albanides. There are 637of papers published in national scientific journals, 33 of papers published in international scientific journals, and hundred papers that have been presented to major success in international scientific meetings [Biçoku T. 2004, Frashëri A. et al. 2010, Papa A. 2001, Rama M. 1995].

Unfortunately, during a very difficult post communist transition among 1990 to 2012, geological research and other scientific activities, including the geophysics went downhill. Geophysical companies were reformed and closed, the volume of work has fallen to the minimum possible, leading to zero discovery of oil and gas, as well as solid useful minerals. The geophysics branch in the Polytechnic University of Tirana was recently closed. There is only option for t Scientific Master Diploma on geophysics. Many of the best geophysicists have migrated and actually work in their specialty in France, U.S.A., Canada, etc.

Despite all these processes for geophysics and geological researches, the Albanian geophysicists currently in Albania are trying to save the geophysics in the conditions of the Albanian market economy. We have started to widen the field of the application of geophysics in other areas. We are convinced that the geophysical surveys, with modern equipment and software, are as important to geological exploration and studies as the X-ray equipment and echo-sounds are to the doctors. Therefore, geology without geophysics risks a return to the nineteenth-century level.

Last two decades represent the period of extension of application fields of geophysical methods for solving geotechnical tasks, hydrogeological research , micro zoning of the main cities of Albania, geothermal studies and evaluation of geothermal energy, geoenvironment studies and its impacts assessments, archaeological geophysics, etc. An important contribution has been given by joint projects with other institutions and academics as well as professionals from leading countries in the field. Unfortunately, Geotechnical and Environmental Geophysics surveys, there are not to the extent appropriate of modern techniques and technologies, particularly for the evaluation of natural geologic hazards.

However, in order to assess the new scientific research, inter alia, it is necessary to ask and analyze what was done, how it was done, and to determine future goals and objectives. In order to present a modest contribution in this direction, we have made a review of the Albanian Geophysics in the years 1950 to 2012.

We bow respectfully to Albanian geophysicists: to students, to our colleagues and friends during the years, with which we share the joys, achievements and difficulties of research works, with which we sleep in the stiffing and the rainy days in the mountains, in tents that they often leak. Them to dedicate this writing; sacrifices of their families, with much love and care they supported to perform the duties of their passions in life, with dedication throughout Albania.

For conducting research have worked 289 engineers geophysics geophysics, as well as dozens of physicists, electrical and electrinics engineers, etc. Among whom many scientific have scientific degrees and titles. In the field of applied Geophysics contributed valuable Alfred Frashëri, Ali Mema, Aleko Stamata, Sunrise Luari, Anastas Dodona, Betim Muco, Çaush Xhufi, Daver Canon Eduard Sulstarova, Enrico Veizi, Hasan Topçiu, Hidai Haxhiu Fatmir Fezga, Ferdinat Dafa, Jani Skrame Jorgji fluid, Kliti alder, Llambi Langora, Ligor Lubonja, Llambro Duni, Naun Priftaj, Neim Cavani, Novruz Kodheli, Nikolin Leka Nikola Zendeli, Pertef Nishani, progress Alikaj, Radium Avxhiu, Rushan Lico, Salo Arapi, Safet Dogjani, Salvator Bushati, Siasi Koçiu Spiro Cosmas, Stavro Dimas, Shyqyri Aliaj, Teki Biçoku, Thanas Anthony, Rainbow Dhrami, Veronika Peci, Wilson Bare, Wilson SILO, Vladimir Veizaj, etc.., etc..

1 THE ROLE OF GEOPHYSICAL METHODS IN THE FRAMEWORK OF INTEGRATED OIL & GAS EXPLORATION

Integrated geophysical exploration for oil and gas had the reflection seismic survey as the main method. Besides its, prospective regions for oil and gas have mapped by gravity surveys. Have been used also some vertical electric soundings. Successful experiments, but in small volume, were also made for direct search of oil and gas reservoirs by complex of methods: natural electric field, radiometric and magnetic surveys. All deep oil and gas wells have studies by integrated well logging methods.

History of the development of seismic work can share in the four main stages:

1. 1952-1970: Oscilographic recording, and manual processing and interpretation of the seismic data. The works were carried out in lowland terrains.

2. 1970 to 1978: Analog magnetic recording, multiple coverage profiling, and surveys were extended also in rugged terrain, with complicated geology.

3. 1980 to 1990: Digital recording and processing of the seismic data, the widely used multiple coverage, and improvement data processing.

4. After 1990 there were gradually declining to zero geophysical exploration works for oil and gas by Albanian geophysicists. Actually, performing of the seismic exploration there is realized by foreign companies.

Gravity survey on the scale 1:100.000, and 1: 50,000 and 1:25.000 have covered the whole perspective territory for oil and gas bearing.

In 1978 has restarted application of the vertical electric soundings with depth of investigation about 2.5 km. The object for the electric soundings have been identification of the limestone structure top, and evaluation of the sandstone content in the Neogene molasses in onshore, and in the Albanian Adriatic shelf, etc.

In the years 1978-1982 was successfully experimented direct exploration of the oil and gas reservoirs by integrates methods: natural electric field, magnetic and radiometric surveys.

Albanian Well Logging Service has celebrated 80th anniversary. The systematic geophysical study of all oil and gas deep wells was begun in 1950, with electric logging, well deflection and factice diameter measurements. The temperatures were recorded in well with electric thermometers. Were performed first experimentation of the gamma logging, and gas logging.

The main feature of the later period, the launch of sixty years, was the step to the full quantitative and qualitative interpretation of logging data, performance of the logging in the well, and determination of the physical properties of the terigjene productive horizons.

Currently, unfortunately even this direction of the Geophysics is abolished, because there are stopped the drilling of the exploration and development deep wells by Albanian Oil and Gas Industry. There remained only a small nucleus in the oil industry, to study any of Albpetrol well.

2 THE ROLE OF GEOPHYSICAL METHODS IN THE FRAMEWORK OF INTEGRATED EXPLORATION OF SOLID MINERALS

Geophysical methods, used in the framework of integrated geological-geophysical-geochemical exploration, have an important role in search for solid minerals. The role of geophysical methods has depended on many factors such as the kind of mineral to be prospected, the stage of the search, and the kind of problems to be solved.

Application of geophysical methods has been concentrated in two major directions:

1. ***Direct search*** *for many kinds of solid mineral deposits such as copper sulphide, polymetalic, and chrome ores.*

The methodology of the geophysical exploration for copper ores deposits (from the 1930's until today) and chrome resources (from 1958 until today) in Albania was developed in conformity with the geological tasks to be solved and the scientific-technical levels of the geophysical methods.

Geophysical copper deposits search and development has high efficiency. The geophysical methods application has been depended by **ore body depth** of location, and kind of the mineralization type. Geoelectrical surveys have been main prospecting methods, through following evolution:
- **1953-1960** discovery have been based on geophysical self-potential method and resistivity profiling for massive and shallow ore bodies, where redox phenomenon is developed.

- **1973-19**89- geophysical exploration was based on application of induced polarization, which was the main exploration method at the depth, and self- potential method and resistivity profiling for detalization and selection massive ore bodies from mineralization zones.

During the **phase of detailed exploration** have been applied: the induced polarization method, EM profiling, the radio wave floodlighting method, mise a la mase method, the borehole vectorial magnetic surveys, the electrical and gamma-gamma logging. In 1978, usefully was started developing of the IP/Resistivity "Real Section".

In Albania was gained a good experience for the integrated geological-geophysical-geochemical **exploration of chrome deposits** and were set up integrated methods to be used in ground and underground surveys. The geophysical methods have an important contribution for discovery in series of chromite deposits. Only during 1989 year, in the ultrabasic massif of Bulqiza were projected 356 boreholes to verify geophysical anomalies in 35 objects. From them, 145 boreholes have discovered mineralized horizons.

The geophysical complex for direct chromite deposit search includes surface mapping by gravity, magnetic and IP methods. Underground geophysical surveys were carried out for the search surrounding space of the mine works and boreholes. In order to get the geophysical documentation of the boreholes, have been performed electrical and radiation (density/selective gamma-gamma and neutron activation) logging.

For the search of chrome deposits, a further and continuous improvement is required to improve the coordination of the direct search for ore bodies with the geophysical methods used for geophysical-structural mapping and under-ground surveys. This is connected with the fact that petrophysical properties of the ore and those of surrounding rocks vary in a wide range, sometimes overlapping each other. All this factors have their influence on the effectiveness of the geophysical search for chrome ore bodies, which is lower than for copper ore bodies.

Through the exploration activity we learned in practice that the ores and surrounding rocks are characterized by unique value of the physical properties. The inverse is not true, i.e. the same magnitude of a physical property or feature may be the same for several minerals and rocks. For example, good electrical conductors are not only massive sulphides but kaolin and clays as well. Therefore, a single geophysical method and one physical feature of the medium are not sufficient to solve the problem. To find the solution is necessary to know the complex of different physical properties. Consequently, exploration has been integrated, with complex of the geophysical methods**.**

Perturbations caused by the topographic effect, variation of thickness and composition of the overburden beds, should be considered carefully to avoid false signals and spurious anomalies. To solve this problem, started from 1973 the application of mathematical methods and computer's data processing and interpretation.

Heights year's period was characterized by **e**xploration of copper sulphide massive and disseminated ore deposits, which are located at the depth up to 700-800 m. The main exploration method has been induced polarization method, and underground surveys. The increase of the depth of investigation has been supported by mathematical modeling.

These achievements were based on further methodological and organizational improvements organization of the geological-geophysical surveying in Albania. Complex geological-geophysical-geochemical teams for the search of copper deposits were created to carry out mappings at scale 1:5000 and detailed studies of anomalies at scale 1:2000. **This was the key of success.** The implementation of geophysical methods in search for mineral resources, in general, and for mineral ore bodies, in particular, has been based also

on methodological criteria: **moving from known areas toward unknown**, which made possible to discover the biggest copper fields in Albania, which consisted of 11 copper deposits, located at different topographic levels from surface down to depth of several hundred meters.

In the mid eighty's year's period there have been solved also two other problems:

- The discrimination of massive ore bodies in great depth, between mineralized zones.
- The discrimination of anomalies composed by the superimposed of the effect from the sulphide ore bodies and from the nearby serpentines individualization.

These complicated problems stand in front of search for all geophysicists of these days. To solve them we needed another improvement of the methodology of geophysical search, which started at the second half of the years eighty up to date.

After 1990 year up to present, geophysical exploration of the copper and chrome deposits with the minimal field volumes there are realized by foreign companies, which actually are worked in Albania.

2. ***Geophysical structural mapping*** *in the complex with geological mapping in order to recognize the geological settings of perspective zones and ore control factors.* The contribution of geophysical studies in the recognition of tectonic the zones and their relationship, is well known in Albania.

The gravity and magnetic mapping at scales between 1:25.000-1:200.000. A particular attention has been paid to petrophysical studies as well.

3. DEVELOPMENT OF THE GRAVITY AND MAGNETIC SURVEYS

The development of magnetic and gravity surveys were performed in several directions:

- Expanding the field of use of gravity and magnetic methods for solid ores deposits exploration, including copper, chromium, and iron - nickel, bauxites, asbestos, heavy mineral placers.
- Study of magnetic properties and density of minerals and rocks.
- Building of the magnetic and gravitational country networks of Albania and their connection to international ones.
- The compilation of algorithms and standard software for processing and interpretation of magnetic and gravity data.
- The major results present the Bouguer Anomalies of the Gravity Field and Magnetic Field of Albania Maps, at the scale 1:200.000.
- Performing of the paleomagnetic studies in all Albanian territory, according to the bilateral projects Albania Austria, France, and Greece.

4. RADIOMETRIC STUDIES AND EXPLORATIONS

The first measurements of natural radioactivity in Albania, carried out in 1958-1959. Until 1990, radiometric studies and research have been secret.

Ninety years brought opening of radiometric research. Radiometric researches have applied to solve many important problems, which have not the relations with the Uranium explorations:

- Implementing radiometric gamma spectrometric determinations by radioactive elements U, Th, K, in the framework of an international project, and regional survey for Geochemical Atlas of Albania.

- Regional radiometric studies according to the total gamma radiation parameter. Has been realized the study "Natural Radioactivity of Albania."

Currently, radiometric studies are oriented to solving environmental problems.

5. GEOTHERMAL STUDIES

Results of the geothermal studies and researches have been presented in the monographs: "Geothermy of Albanides" (1990), " Geothermal Atlas of Albania" (1995), "Atlas of Geothermal Resources in Albania" (, 1996, published 2004), "Geothermal Atlas of Europe" (1992) published by Geographisch-Kartographische Anstalt Gotha, Germany, and "Atlas of Geothermal Resources in Europe", European Commission (2002). Monograph "Geothermal energy resources in Albania and platform for their use", published by Faculty of Geology and Mining, Polytechnic University of Tirana, (2010).

6. SEISMOLOGICAL STUDIES

Albania's seismological network was established in the period up to 1979, with fourteen stations in major cities of the country. During this period have been making Albanian seismological network part of the European and global network through the International Central Bureau of Seismology in Strasbourg, France.

Among major seismological study was conducted "Seismic Zoning Map of Albania" (1972), "Catalog of Earthquakes in Albania" (1975), and "Seismological Zoning of Albania" (1979), published by Academy of Sciences of Albania. Eighties years were period when spread massively seismological studies for solving engineering problems, realizing complex seismological- engineering and geotechnical engineering micro zoning of leading cities of the country.

Continued high levels of international cooperation on the problem of seismic risk the corner of the Balkans, in the event of the Assembly of European Council of Seismology, as well as in projects of UNESCO. Are conducted seven joint international projects and has collaborated on eight projects under the National Program for Research and Development for the publication of seismological, seismological-engineering, neotectonic and of the geological risks maps.

7. FORMING OF THE GEOPHYSICIST ENGINEERS AND THEIR POST GRADUATE QUALIFICATION

Has given great contribution in development of the geophysics in Albanian by Section of Geophysics in the Faculty of Geology and Mining, Polytechnic University of Tirana in both directions: engineers forming, their postgraduate qualification, and scientific research.

Forming of geophysical engineers since 1961 and their postgraduate training was realized in the Branch of Geophysics, Section of Geophysics in Department of Earth Sciences, Faculty of Geology and Mining, Polytechnic University of Tirana. The period of study has been five years for engineers, taken 1-2 years (postgraduate school) and three years for doctoral studies. Current main course of applied geophysicist engineers have been exploration of the oil and gas reservoirs, other solid minerals deposits, hydrogeological research, engineering and environmental studies. During the period 1961-2008 are compiled and continuously improve the curriculum, they respond better to the requirements of time and level of scientific and technological research and geophysical studies and exploration.

In the Framework of implementing the Bologna Protocol, is closed Branch of Geophysics. Under the new curricula, after the first three years of common cycle (Diploma Bachelor for Georesources and Geoinformatics), a geophysical option is in the second year of the Scientific Master degree. With this curricula, , as have been prepared in implementation of Bologna Protocol, results level landing of the scientific and professional formation of geophysical engineer.

In the Geophysical Branch have been formed 303 of engineering geophysics, and are specialized in geophysics and were re-qualified as geophysicists many physicist. Since 1962, Geophysical Brach was also conducted postgraduate qualification of 48 doctors of sciences.

1. Mining geophysics: Application of the new methods and technologies in Albania:

- Induced polarization method (1962 up to present)
- Micromagnetit surveys (1967)
- IP & RD Real section (1978 up to present)
- Increasing of depth of geophysical investigation (1984 up to present)

2. Mathematical and physical modeling for geoeelectric, gravity and magnetic methods, and inversion in geophysics. Compilation of the algorithms and software's for data processing and interpretation.
3. Extension of the application fields of geophysical methods for exploration of: chromite, asbestos, bauxites, heavy, rare and precious mineral placers, geotechnical and environment investigations, hydrogeological research, application of the natural electrical field for direct search of oil reservoirs.*5. Marine geophysics* (1974-1990): Design and construction of the marine geoelectrical station, marine vertical electrical sounding and profiling, and participation in performing of the marine integrated geological-geophysical studies of the Albanian Adriatic Shelf and design of deep wells for gas exploration in Durres Bay.
6. Regional geophysical studies: Geothermal (1989 up to present), Palomagnetic (1989-1997).

8. *Engineering and environmental geophysics* (1982 up to present), **Publication of the books:** The Section of Geophysics has completed all courses with textbooks, published in the period 1963-upo to present: 19 books for Branch of Geophysics, 4 books for Geological Branch and 5 monographs.

8. WHAT SHALL WE DO FURTHER - AS CONCLUSIONS

Twenty last year's represent the period of expansion in the field of application of geophysical methods to solve the geotechnical tasks: soil and bedrocks study in the construction areas, control of the dams and landslides, hydrogeological explorations, micro zoning of the main cities in Albania, the study and evaluation of geothermal energy, etc. in Albania. Actually are taken the first positive results, first experience, as well as problems of the beginning.

Currently, the geophysical prospecting of oil and gas reservoirs, copper and chromium and other solid minerals deposits are suspended entirely by Albanian geophysical teams. Cessation of work and geophysical studies extremely serious consequences for future geological researches: The geological explorations remain free modern research methods, and turn to the thirty years of the last century level. With the termination of geophysical explorations, the teams were destroyed and lost a half century of their experience, well known also from prestigious institutions of advanced countries.

Today, for Albanian petrol and mining industries are important to take the proper development and implementation of Applied Geophysics directions in accordance with the requirements of market economy, for oil & gas and solid minerals explorations, using modern methods and surveys technology. At the same time, it is necessary to begin implementation of new technologies for geophysical surveys of shallow depths for solving of the geotechnical tasks, environmental control, environmental impacts assessment, urban planning, water exploration, medical geophysics, archaeological sites searches, etc.

In response to the demands of time and development directions of the geophysics in the last two decades, there were worked successfully for the creation of Engineering and Environmental Geophysics in Albania. Geophysical methods have been applied in many fields: In-situ seismic and geoelectric topographies' for dams investigation, the slope stability evaluation and landslides study, soil and bedrocks study in construction and dam areas, of highways, tunnels, etc., for karst areas exploration, quality assessment of the concrete during construction works, and in the airport runway, water exploration, for study of the urban and industrial landfills, also for the assessment of the environmental impacts.Engineering and environmental studies are performed by the same methods, technologies, and equipments that are used for search of minerals. So, at the present, the geophysical and environmental engineering investigations are used the technology and equipment eighties years period, with exceptions when were working in the framework of European project. Albanian geophysical teams are necessary to obtain modern equipment to solve these new geological tasks, presented by today the market economy in Albania. In particular, this situation is very serious for the study of construction areas, of roads, the investigation of the hydrotechnic constructions like dams, the evaluation of the slope stability and landslides, the assessment of geological hazards, water exploration, etc.

For the forming of the yang geophysical engineers, currently the problem is the preparation and implementation of curricula and programs in accordance with the requirements of the Bologna Protocol, and actual scientific and technologic level of the geophysical methods. Future geophysicists should be able to realize the oil & gas, and solid minerals exploration because Albania is riche country with natural resources, in parallel is necessary to be able to solve also the engineering and environmental problems, applied surveys with modern technology and digital processing of data.

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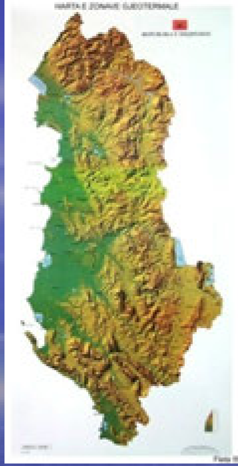
KONFERENCE JUBILARE

"90 VJET GJEOLOGJI SHQIPTARE"



GEOPHYSICAL CONTRIBUTIONS DURING 90 YEARS OF ALBANIAN GEOLOGY, AND FACING OF THE TRANSITION CHALLENGES

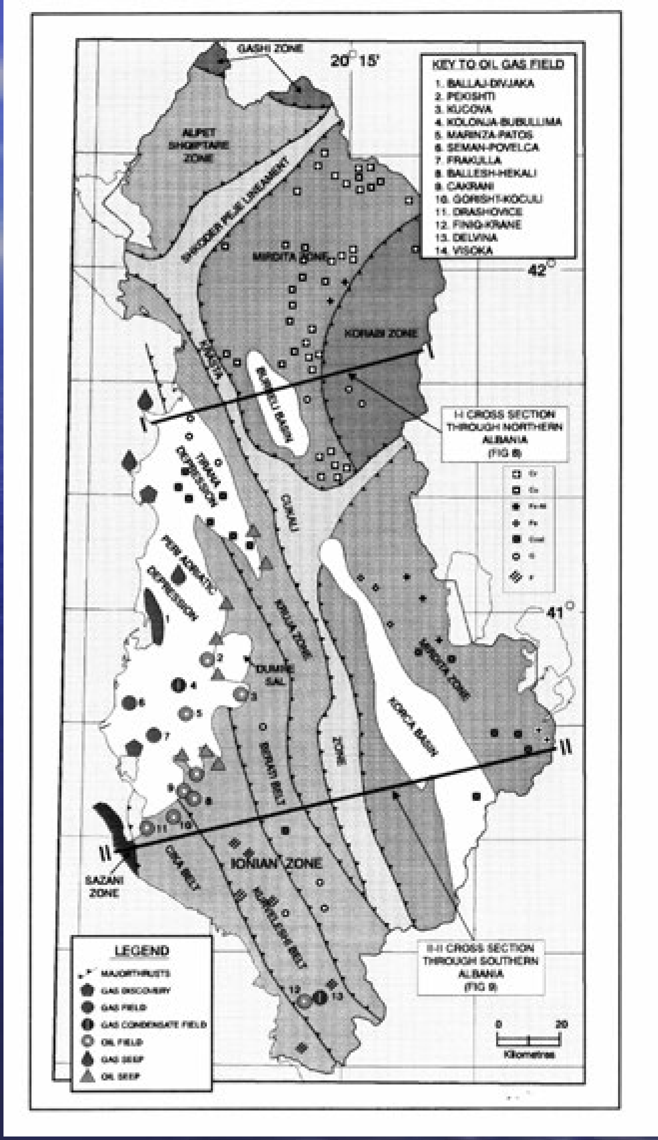
Alfred FRASHËRI , Salvatore BUSHATI
Faculty of Geology and Mining
Academy of Sciences of Albania

Tirana, October 2012

- In 90 anniversary of the Geology of Albania we bow respectfully to Albanian geophysicists: to students, to our colleagues and friends during the years, with which we share the joys, achievements and difficulties of research works, with which we sleep in the stiffing and the rainy days in the mountains, in tents that they often leak. Them to dedicate this writing; sacrifices of their families, with much love and care they supported to perform the duties of their passions in life, with dedication throughout Albania.

- For conducting research have worked 289 engineers geophysics geophysics, as well as dozens of physicists, electrical and electrinics engineers, etc. Among whom many scientific have scientific degrees and titles. In the field of applied Geophysics contributed valuable Alfred Frashëri, Ali Mema, Aleko Stamata, Sunrise Luari, Anastas Dodona, Betim Muco, Çaush Xhufi, Daver Canon Eduard Sulstarova, Enrico Veizi, Hasan Topçiu, Hidai Haxhiu Fatmir Fezga, Ferdinat Dafa, Jani Skrame Jorgji fluid, Kliti alder, Llambi Langora, Ligor Lubonja, Llambro Duni, Naun Priftaj, Neim Cavani, Novruz Kodheli, Nikolin Leka Nikola Zendeli, Pertef Nishani, progress Alikaj, Radium Avxhiu, Rushan Lico, Salo Arapi, Safet Dogjani, Salvator Bushati, Siasi Koçiu Spiro Cosmas, Stavro Dimas, Shyqyri Aliaj, Teki Biçoku, Thanas Anthony, Rainbow Dhrami, Veronika Peci, Wilson Bare, Wilson SILO, Vladimir Veizaj, etc.., etc..

Albania is rich with natural resources: oil, gas and solid minerals.



Integrated geological-geophysical-geochemical prospecting been have discovered and developed tons of solid mineral deposits, and oil & gas reservoirs in Albania.

The economic capacity of the Albanian Mining and Petroleum Industries, it is possible to present by maximal extractions during 1984:

- 1,007,000 tons/year of copper minerals,
- 960,000 tons/year chromites.

About 20 million tons of copper minerals and 21 millions tons of chromites have been extracted.

- Oil production reached a peak of *2.250.000 tons /year in 1973*.
- Up until 1990s, there were extracted 49,5 million tons of oil, about 12 million cubic meters of natural, and
- 47 million tons of coil.

- The Bitumen from the Selenica mines in southern Albania has been extracted since the ancient times. Illyrian tribe of pirusts was well known for copper processing. An activist of the Albanian Renaissance, the philosopher
- Sami Frashëri, in his book **"Albania, What It Was, What It Is, and What Will It Be** (1899), wrote "…it is necessary to explore all metals all over Albania … In the capital of Albania, in addition to secondary schools must be a university, and an academy….. to develop in Albania the literature, history,…. and geology, etc.”.
- Nearly half a century later, a politician Mehdi Frashëri in his book "**The Albanian Problem**" (1944) wrote: "... At near future, Albanian oil in Kuçovo as well as in Patos will form a source of national wealth and a key target for state revenues " and "… in Albania there have been explored some ores, which can also reasonably be used for developing the economy and industry of the country….”. ***Procuring fuel, as in time of peace as well as in time of war has taken a great importance that plays a leading role in foreign policy of states. For these reasons fuel in majority of states have been the monopoly items. On the one hand to give sufficient revenues case of the state, on the other side to have under control; for all of its cases if the monopolization of the fuels in foreign hands is a suicide, that in case of need the state lacks main factor of each movement*** (p110).

- First gravity & magnetic surveys, Vertical Electrical Soundings, and well logging have been performed by Italian geophysicists during 1931-1942 period.
- Geophysical research in fifty's years: by Soviet and German geoph.
- From 1952 here returned studies two first Albanian engineers. At that time were formed also the first geophysicist's technicians.
- **After 1961, all geophysical surveys have been performed by Albanian geophysicists.**
- For two years in the seventy's years, the Albanian geophysicists have worked together with the Chinese geophysicists.
- **With two Albanian geophysicists engineers started the Albanian geophysics in 1952. Today, after 60 years, there are 304 geophysicists, as well as tens of physicists, electrical engineers, etc. that are working on exploration and geophysical surveys. Among them are 48 doctors of sciences, 7 professors, 1 assistant professor, 9 and 12 leading researchers and masters of the research, respectively.**

- **Albanian Geophysicists** have established since 1989 **Geophysical Society of Albania** (GSA), which is part of the **Albanian Association of Geoscientists and Engineers** (AAGE). GSA is a Associated Member of **the European Association of Geoscientists and Engineers** (EAGE) and is part of the **Balkan Geophysical Society** (BGS).

- Geophysical explorations in Albania, year by year have been developed as:

  - a complex of methods,

  - as technological level of the surveys and interpretation, and

  - is raised up coordination with other geological and geochemical methods.

GEOPHYSICAL METHODS APPLIED BY THE MEMBERS OF AGS IN DIFFERENT INSITUTIONS AND COMPANYES

GEOPHYSICS	Methods	Application fields			
		Oil & gas	*Mining*	*Engineering-Environmetal*	*Regional*
Applied	Seismic reflection	++		++	+
	Electrical	+	++	++	+
	Gravity	+	+	+	++
	Magnetic		+	+	++
	Well logging	++	+	+	+
	Radiometric		+	+	+
Selsmology	Earthquakes	1. Seismological Surveys Network 2. Seismological zoning of Albania			
	Engineering	1. Seismic Micro Zoning and seismic risk evaluation 2. Seismic monitoring of the hydropower plant dams			
Geothermal	1. Geothermal studies 2. Geothermal energy platform and use scenarios.				

Geophysical Exploration and studies have been performed in the framework of the three Geophysical Enterprises:

- 1. Oil and Gas Seismic and Gravity Enterprise in Fieri City:

4 seismic teams, 1 gravimetric, 1 geoelectrical team,

Marine expedition with seismic, geological and geoelectrical teams.

70 geophysicists engineeris.

2500 km/year of seismic profiling by multiple coverage.

- 2. Oil and Gas Well Logging Enterprise in Patosi City.

30 geophysicists engineers.

Well logging: electric, radioactive and sonic groups,
gas logging groups, perforator groups,
laboratory determination of physical properties of the rocks, and
interpretation group.

Well logging groups carry integrated geophysical study of exploration deep wells (up to 6700 m) for oil and gas, with an annual volume of 80,000 linear meters of exploration wells and tens of thousands linear meters of production wells.

- 3. Geophysical Enterprise of Tirana for mining geophysics.

  106 geophysicists engineers.

  Geoelectrical teams (35-40 km^2/year mapping at the scale of 1:10 000, 1:5.000 and 1:2.000).

  Averagely the same area have covered also by the gravity and magnetic survey.

  In 2008, the restructuring of the Albanian Geological Service, the company was reformed and closed: several specialists went to the Institute of Earth Sciences was established, some remained in the geophysical unit of Albanian Geological Service.
- In Geological & Geodesical Enterprise of the Ministry of Construction and in the Hidrogeological Enterprise of Tirana have two specialized geophysical expeditions for engineering geophysics (1983) and water exploration (1980).

- **Seismological studies** pertain to three areas:
  - Seismotectonic,
  - Seismology, and
  - Earthquake engineering.

- **Teaching of applied Geophysics** has started in **1955** in the Polytechnic Institute of Tirana.
- The formation of geophysical engineers and their post graduate training since **1961** in the Geophysical Branch, Chair of Geophysics, Faculty of Geology and Mining, Polytechnic University of Tirana.

The period of study was five years for engineers, and taken three years for doctoral studies.

Geophysicists of all generations have developed the Albanian geophysics, and have given outstanding contribution to the discovery of eleven oil and gas reservoirs, ten copper deposits, and many other solid minerals.

They have performed also the geophysical regional studies of the Albanides, which are known beyond the borders of the country.

There are 637 of papers published in national scientific journals, 33 of papers published in international scientific journals, and

hundred papers that have been presented in international scientific forums by Albanian geophysicists, ranking among the best Albanian ambassadors in the international community.

Unfortunately, during a very difficult post communist transition between 1990 to 2012, geological research and other scientific activities, including the geophysics went downhill.

Geophysical companies are closed, the volume of work has fallen to the minimum possible, leading to zero discovery of oil and gas, as well as solid minerals.

The geophysics branch in the Polytechnic University of Tirana was recently closed. There are only option for the second cycle, master diploma on geophysics.

Many of the best geophysicists migrated and work in their specialty in France, U.S.A., Canada etc.

- Despite all these processes for geophysics and geological researches, *the Albanian geophysicists currently in Albania are trying to save the geophysics in the conditions of the Albanian market economy.*

- We have started to widen the field of the application of geophysics in other areas and disciplines.

- Geophysical surveys with modern equipment and software are as important to geological exploration and studies as the X-ray equipment and echo-sounds are to the doctors. Therefore, a geology without geophysics risks a return to the nineteenth-century level.

In order to assess the new scientific research, inter alia, it is necessary to ask and analyze:

- what was done,

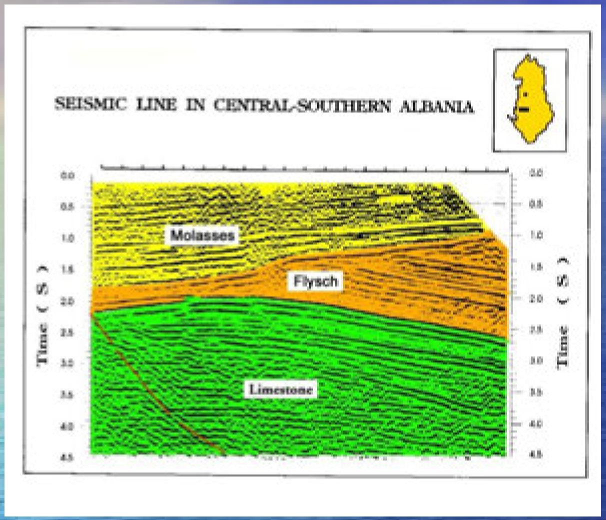
- how it was done, and to determine future tasks and objectives.

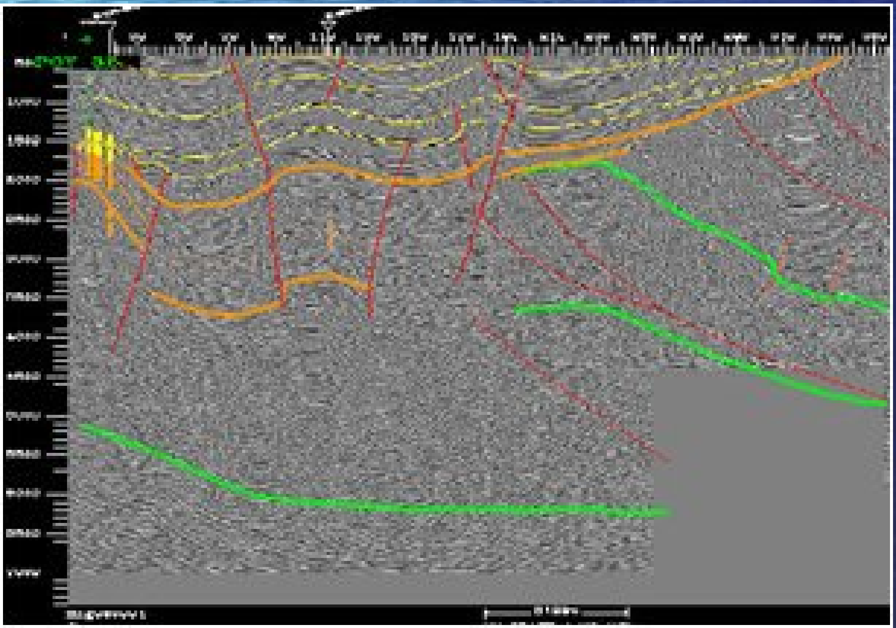
In order to present a modest contribution in this direction, we have made a review of the Albanian Geophysics in the years **1950 to 2012**.

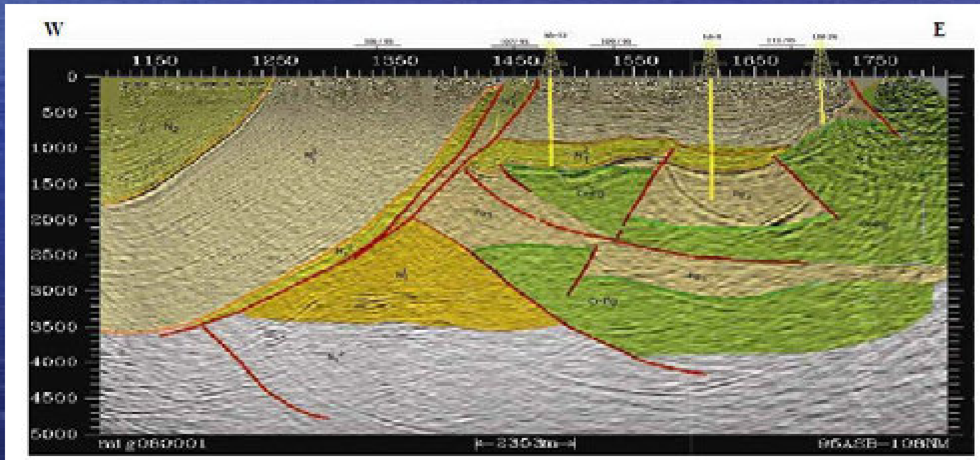
The role of geophysical methods in the framework of integrated oil & gas exploration

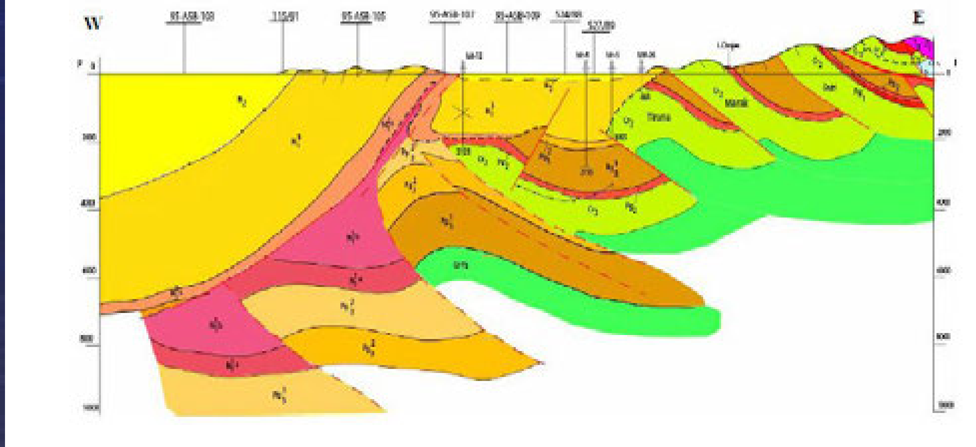
- Integrated geophysical exploration for oil and gas had the **reflection seismic survey** as the main method, in onshore and offshore.
- Perspective regions for oil and gas have been mapped by **gravity surveys**.
- Have been used also some vertical electric soundings.
- Successful experiments, but in small volume, were also made for direct search of oil and gas reservoirs by complex of methods: **natural electric field**, **radiometric** and **magnetic** surveys.
- All deep oil and gas wells have been studied by integrated **well logging** methods.

- Contributions: in discovery of 5 Oil & 6 gas reservoirs









History of the development of seismic work can present in the three main stages:

- **First Stage 1952-1970:** oscilographic recording,
  and manual processing and interpretation.
- **Second stage from 1970 to 1978:** Analog magnetic record.
  multiple coverage profiling,
  digital processing of the seismic data
  rugged terrain
- **The third stage from 1980 to 1990:** Digital recording
  improvement the seismic data processing and interpretation.

After 1990 there were gradually declining to zero geophysical exploration works for oil and gas by Albanian geophysicists. Actually, performing of the seismic exploration there are realized by foreign companies.

Albanian Well Logging Service has celebrated 80th anniversary:

Well logging service has started with electric logging, well deflection, diameter measurements, the temperatures records.

- **Sixty years**: quantitative and qualitative interpretation of logging data, determination of the physical properties of the terrigene productive horizons.
- **Later period:** greater development and geophysical integrated logging of the wells in several directions:

a) integrated studies : electric, gamma-gamma, neutron logging, neutron activation, sonic and electric lateral loggings, the use of radioactive tracers.

b) Quantitative interpretation of geophysical data through computers.

c) Study the physical characteristics of the oil and gas bearing collector rocks: carbonate and terrigene.

Currently, unfortunately even this direction of the Geophysics is abolished, because there are stopped the drilling of the exploration and development deep wells by Albanian Oil and Gas Industry.

The role of geophysical methods in the framework of integrated exploration of solid minerals

- Geophysical methods were important part of integrated geological exploration for solid minerals, first of all for:

    copper, and

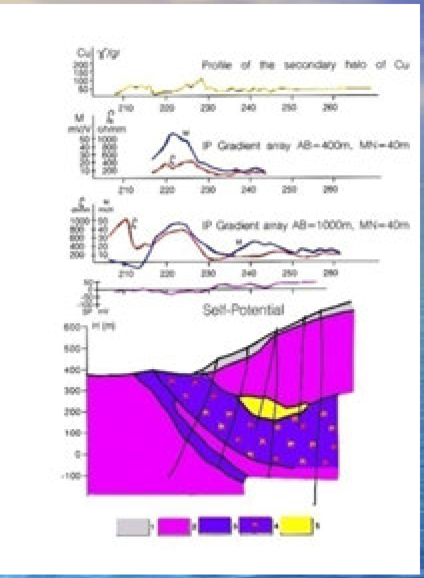
    chromite mineral resources and deposits.

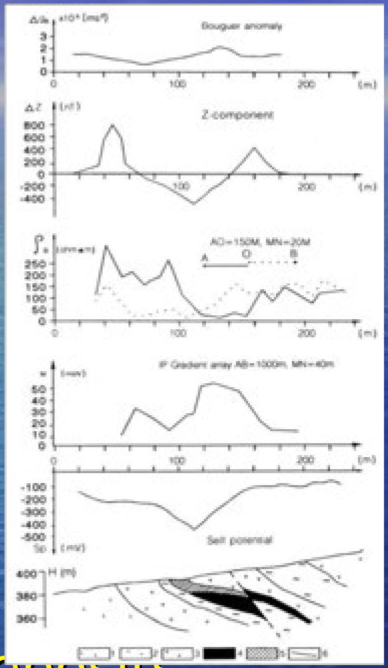
The role of geophysical methods in the complex has been depended on many factors:

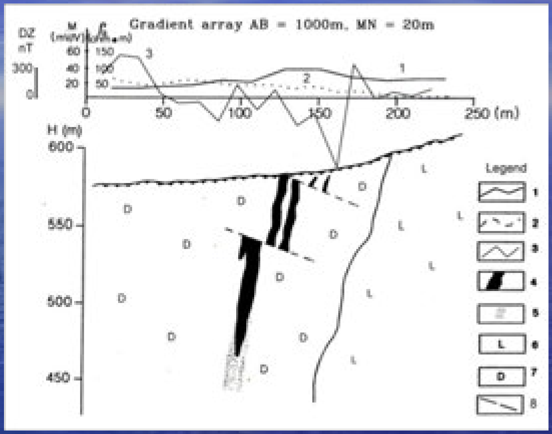
- The kind of mineral to be prospected,
- The stage of the search, and
- The tasks to be solved.

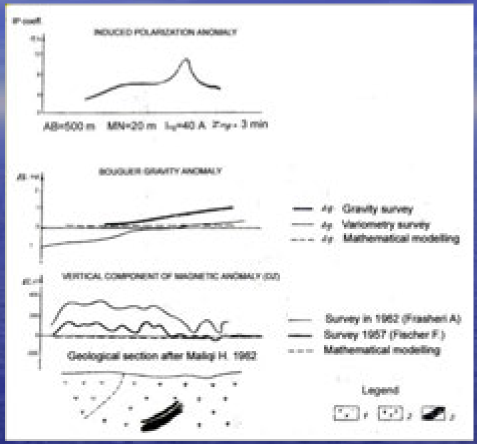
Application of mining geophysics has been concentrated in two major directions:

1. Direct search: **The kind** and **the genetic type** of the mineral have been determinant for the applied methods









GEOPHYSICAL ANOMALIES OVER THE CHROMITE ORE BODIES

VLAHNA DEPOSIST   KAM TROPOJA DEPOSIT

IP and Magnetic anomalies   Gravity & Magnetic Anomalies

Copper deposits

Gjegjani 1959-1961   Qafa Barit 1961-1973

The contribution of the geophysics in the exploration:

13 copper deposits, 145 positive boreholes from, 356 drilled wells for the chrome

The methodology of the geophysical exploration for copper resources (from the 1930's up to date) and chrome resources (from 1958 up to date) in Albania is developed in conformity with the geological tasks to be solved and with the scientific-technical levels of the geophysical methods.

- **Geophysical copper deposits** exploration and development has high efficiency.

The geophysical method application have been depended by **ore body depth** of location, and kind of the mineralization type.

Geoelectrical surveys have been main prospecting methods, through following evolution:

- **1953-1960** discovery have been based on geophysical self-potential method and resistivity profiling) and geological integrated surveys, for massive and shallow ore bodies, where redox phenomenon is developed.

- **1973-19**89- geophysical exploration was based on results of the application induced polarization- main exploration method in the depth, and self- potential method and resistivity profiling for detalization and selection massive ore bodies from mineralization zenes, in the complex with geological-geochemical integrated surveys.

- During the **phase of detailed exploration and developing** have been applied:
  - **- the induced polarization method**
  - **- EM profiling**,
  - **- the radio wave floodlighting method**
  - **- mise a la mase method**,
  - **- the borehole vectorial magnetic surveys**,
  - **- The electrical and gamma-gamma logging**.
- In the exploration activity we were learning that:

  The minerals and surrounding rocks are characterized by unique value of the physical properties, which depend on their physical-chemical conditions. The inverse is not true, i.e. the same magnitude of a physical property or feature may be the same for several minerals and rocks. For example, good electrical conductors are not only massive sulphides but kaolin and clays as well. Therefore, a single geophysical method and one physical feature of the medium are not sufficient to solve the problem. To find a solution is necessary to know another physical property, for example the induced polarization (IP) parameter, or chargeability. **Exploration have been integrated, with complex of the geophysical methods.**

- In 1978, **usefully was started developing of the** **IP/Resistivity “Real Section”.**
- Perturbations caused by the topographic effect, variation of thickness and composition of the overburden beds should be considered carefully to avoid false signals and spurious anomalies. To solve this problem, started from 1973 the application of mathematical methods and computer processing of the field data and their interpretation.
- Heights years period was characterized by **e**xploration of copper sulphide massive and disseminated ore deposits, which are located at the depth up to 700-800 m. The main exploration method has been induced polarization method, and underground surveys. The increase of the depth of investigation has been supported by mathematical modeling.
- These achievements were based on further methodological and organizational improvements organization of the geological-geophysical surveying in Albania. Complex geological-geophysical-geochemical teams for the search of copper deposits were created to carry out mappings at scale 1:5000 and detailed studies of anomalies at scale 1:2000. **This was the key of success.**

In the mid eighty’s years period there have been solved also two other problems:

- The discrimination of massive ore bodies in great depth, between mineralized zones.
- The discrimination of anomalies composed by the superimposed of the effect from the sulphide ore bodies and from the nearby serpentinite individualization.

These complicated problems stand in front of search for all geophysicists of these days. To solve them we needed another improvement of the methodology of geophysical search, which started at the second half of the years eighty up to date. Besides surface geophysical mapping, have been started to develop the underground geophysical surveys. Underground geophysical methods such as the "mise-à-la masse" were implemented since 1959-1960. The radio wave floodlighting method was experimented in 1964. Other methods were added to this complex such as the vector magnetic method and IP surveys in bore hole, and the borehole’s electromagnetic methods of low frequencies, TURAM-TURAM.

The underground geophysical surveys have applied in two directions:

- 1. For the search in the space around and under borehole or galleries, and
- 2. For geophysical documentation of the borehole by electrical and radiometric loggings.

Its objectives were:

- To search of ore bodies in depths 600-700 m.
- To decrease the density of mine works and boreholes
- To decrease the sampling during the drilling process up to the use of drilling without sampling.

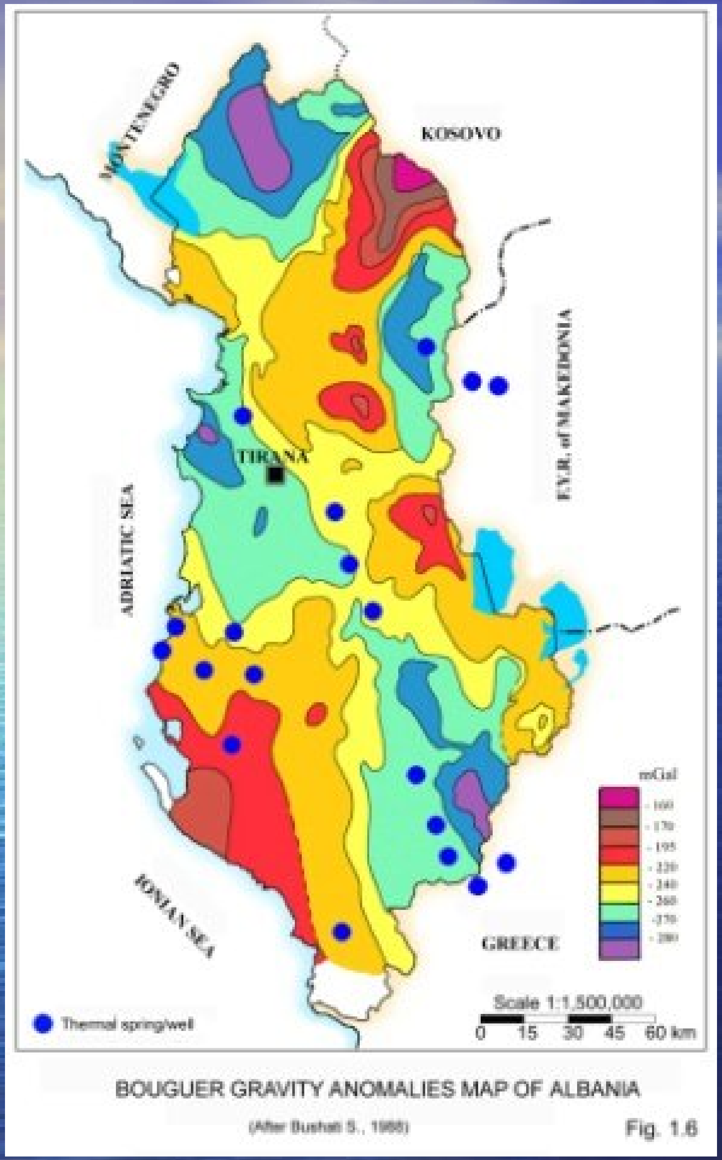
The implementation of geophysical methods in search for mineral resources, in general, and for mineral ore bodies, in particular, has been based also on methodological criteria: moving from known areas toward unknown, which made possible to discover the biggest copper fields in Albania, which consisted of 11 copper deposits, located at different topographic levels from surface down to depth of several hundred meters.

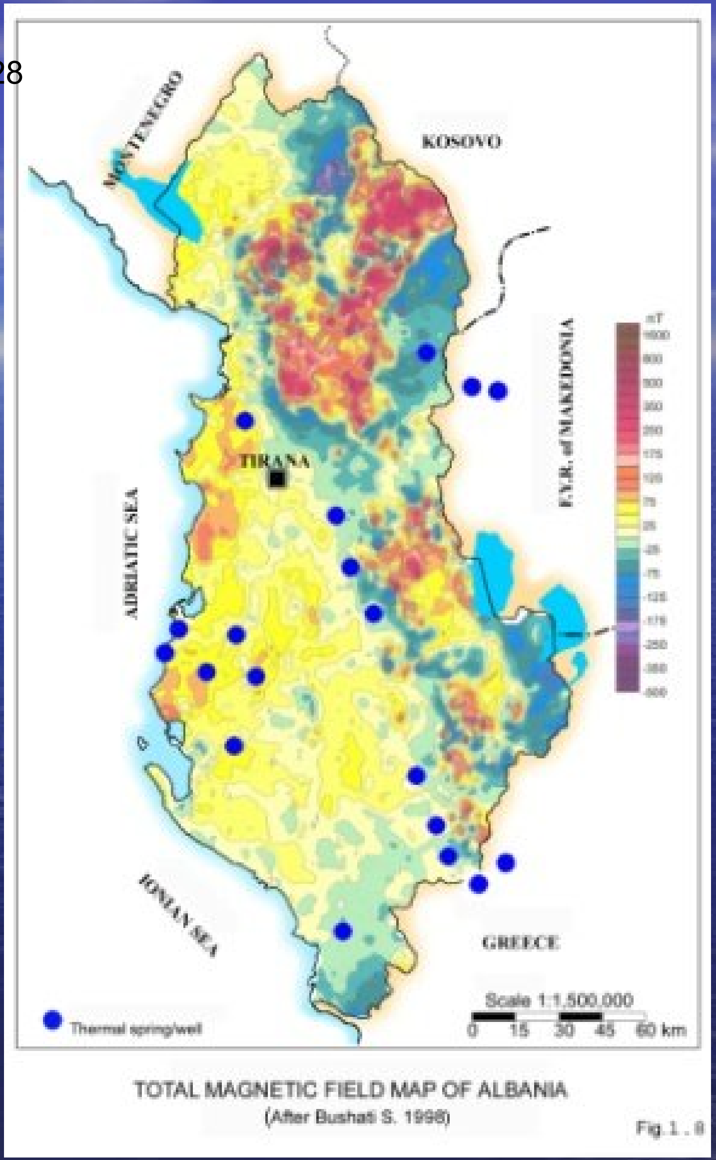
After 1990 year up to present, geophysical exploration of the copper and chrome deposits with the minimal field volumes there are realized by foreign companies, which work in Albania.

2. ***Geophysical structural mapping*** *in the complex with geological mapping in order to recognize the geological settings of perspective zones, and ore control factors.*

The contribution of geophysical studies in the recognition of the tectonic zones and their relationship, is well known in Albania.

- The gravity and magnetic mapping at scales between 1:25.000-1:200.000.
- In some zones of interest seismic lines and electric soundings have been conducted as well, as example in the Neogene mollasic interfosess.
- The geological setting of ore fields has been studied by using gravity, magnetic and electrical methods at scale 1:10,000 and sometimes 1:5,000. IP/Resistivity profiling and soundings have been increasingly employed in detailed exploration.
- A particular attention has been paid to petrophysical studies as well.





Bouguer Gravity Anomalies Map, at scale 1:200.000

Total Magnetic Field Map at scale 1:200.000

Development of gravity and magnetic surveys

The development of magnetic and gravity surveys was performed in several directions:

- Expanding the field of use of gravity and magnetic methods, as well as technology of surface mapping and underground surveys. Magnetic surveys have been applied for solid ores deposits exploration, including copper, chromium, iron - nickel, bauxite, asbestos, heavy mineral placers.
- Study of magnetic properties and density of minerals and rocks.
- Building of the magnetic and gravitacional country networks of Albania and their connection to international ones.
- The compilation of algorithms and standard software for processing and interpretation of magnetic and gravity data.
- The major results present the Bouguer Anomalies of the Gravity Field and Magnetic Field of Albania Maps, at the scale 1:200.000.
- Performing of the paleomagnetic studies in all Albanian territory, according to the bilateral projects Albania Austria, France, and Greece

Radiometric studies and explorations

The first measurements of natural radioactivity in Albania, carried out in 1958-1959. Until 1990, radiometric studies and research have been secret.

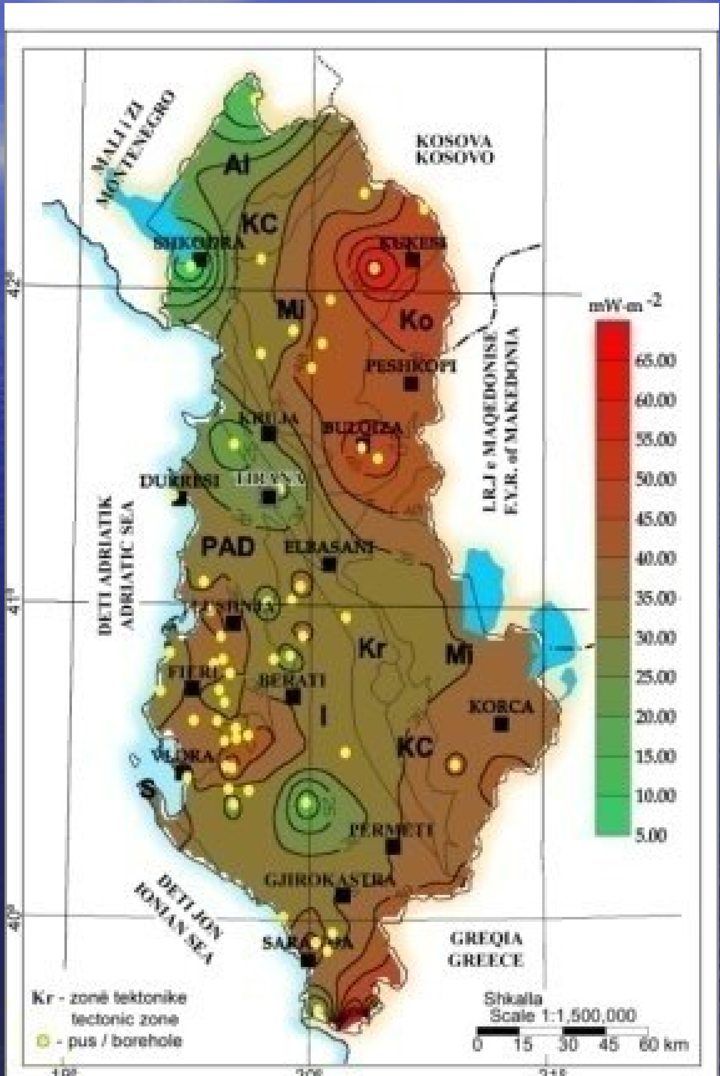
During the ninety years were opened the radiometric research that have been oriented to solve many problems, which doesn't not have the relations with the Uranium explorations:

- Gamma spectrometric determinations by radioactive elements U, Th, K in geological samples, in the context of an international project, and for Geochemical Atlas of Albania.
- Regional radiometric studies according to the total gamma radiation parameter. Has been realized the study "Natural Radioactivity of Albania."

Currently, radiometric studies are oriented to solving environmental problems

Geothermal studies

Results of the geothermal studies
have been presented in the monographs:
“**Geothermy of Albanides**” (1990),
“ **Geothermal Atlas of Albania**” (1995),
“**Atlas of Geothermal Resources in Albania**”
(1996, Published 2004),
“**Geothermal Atlas of Europe**” (1992)
published by Geographisch-
Kartographische Anstalt Gotha,
Germany,
“**Atlas of Geothermal Resources in Europe**”,
European Commission (2002).
“**Geothermal energy resources in Albania and platform for their use**”, Monograph published by Faculty of Geology and Mining, Polytechnic University of Tirana, (2010).



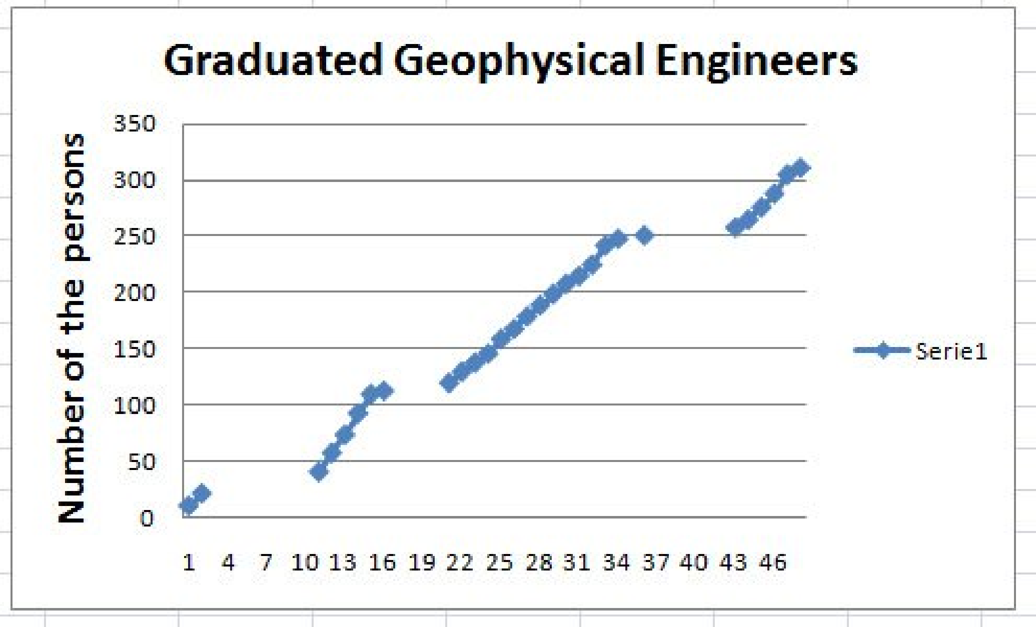
Harta e dëndësisë së fluksit të nxehtësisë
Heat Flow Density Map
Fleta / Plate 16

Seismological studies

- **Albanian seismological network** (from 1979) has fourteen stations in major cities of the country, is part of the European and global network, International Central Bureau of Seismology in Strasbourg, France.
- Major seismological study: "**Seismic Zoning Map of Albania**" (1972), "**Catalog of Earthquakes in Albania**" (1975), and "**Seismological Zoning of Albania**" (1979).
- Eighties years were period when spread massively seismological studies for solving engineering problems, realizing complex seismological- engineering and geotechnical engineering micro zoning of leading cities of the country. Continued high levels of international cooperation on the problem of seismic risk the corner of the Balkans, in the event of the Assembly of European Council of Seismology, as well as in projects of UNESCO.
- Are conducted seven joint international projects and has collaborated on eight projects under the National Program for Research and Development for the publication of major seismological maps, seismo-engineering, neotectonic and the geological risks maps.

7. Forming of the geophysicist engineers and their post graduate qualification

Great contribution in development of the geophysics in Albanian is presented by Section of Geophysics in the Faculty of Geology and Mining, Polytechnic University of Tirana in both directions: engineers forming , their postgraduate qualification, and scientific research.



In the Geophysical Branch have been formed **304 of engineer geophysics**, were specialized in geophysics many physicists.

Since 1962, Geophysical Brach has also conducted postgraduate qualification of 48 doctors of sciences.

- The period of study has been five years for engineers, taken 1-2 years (postgraduate school) and three years for doctoral studies.

- During the period 1961-2008 are compiled and continuously improve the curriculum, they respond better to the requirements of time and level of scientific and technological research and geophysical studies and exploration.

- In the Framework of implementing the Bologna Protocol, is closed Branch of Geophysics. Under the new curricula, after the first three years of common cycle (Diploma Bachelor for Georesources or Geoinformatics), a geophysical option is in the second year of the second two yeas cycle (Scientific Master's degree). **With this curricula, results level landing of the scientific and professional formation of geophysical engineer.**

Scientific research activity of the Geophysical Section professors, in the collaboration with geophysicists of the Mining and Oil & Gas industries during 1961-2012

*1. **Mining geophysics**:* For copper, chromite, bauxites, etc. exploration:

Application of the new methods and technologies in Albania:

- Induced polarization method (1962 up to present)
- Micro magnetit surveys (1967)
- IP & RD Real section (1978 up to present)
- Increasing of depth of geophysical investigation (1984 up to present)

2. Mathematical and physical modeling for geoelectric, gravity and magnetic methods, and inversion in geophysics. Compilation of the algorithms and software's for data processing and interpretation.

3. Extension of the application fields of geophysical methods for exploration of: chromite, asbestos, bauxites, heavy, rare and precious mineral placers, geotechnical and environment investigations, hydrogeological research, application of the natural electrical field for direct search of oil reservoirs.

4. ***Participation in integrated geological-geophysical*** *studies* for design of exploration oil and gas deep wells (1973-1992).

5. ***Marine geophysics*** (1974-1990): Design and construction of the marine geoelectric station for marine vertical electrical soundings and profiling, and participation in performing of the offshore integrated geological-geophysical studies of the Albanian Adriatic Shelf and design of deep wells for gas exploration in Durresi Bay.

6. ***Regional geophysical studies***: Geothermal (1989 up to present), Palomagnetic (1989-1997).

7. ***Geophysical well logging*** *and over normal pressure studies*

8. ***Engineering and environmental*** *geophysics* (1982 up to present),

9. Publication of the books: The Section of Geophysics has completed all courses with textbooks, published in the period 1963-up to present: **19** books for Branch of Geophysics, **4** books for Geological Branch and **5** monographs.

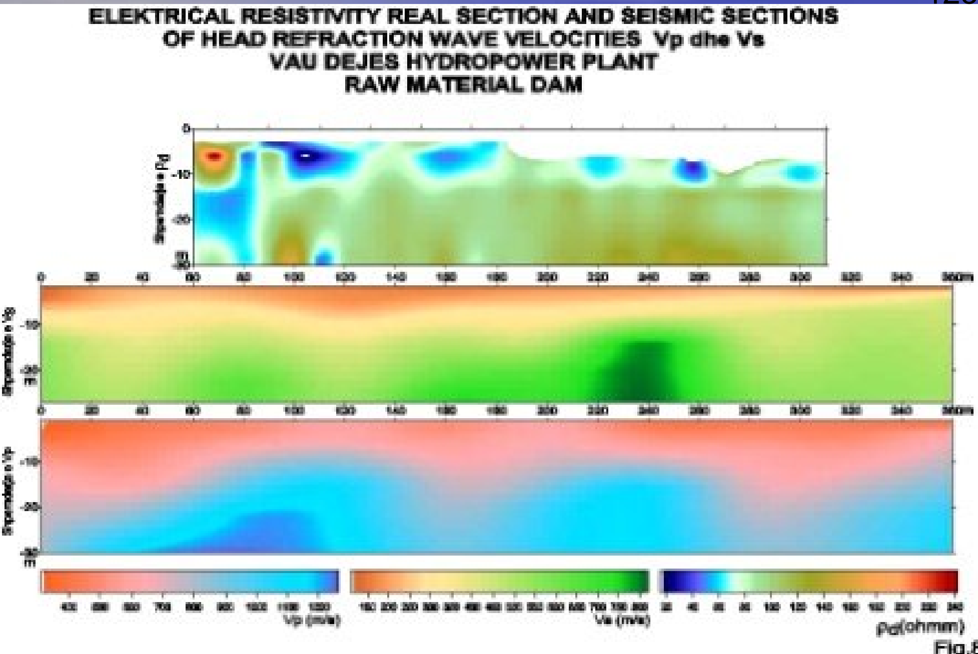
What shall we do further - as conclusions

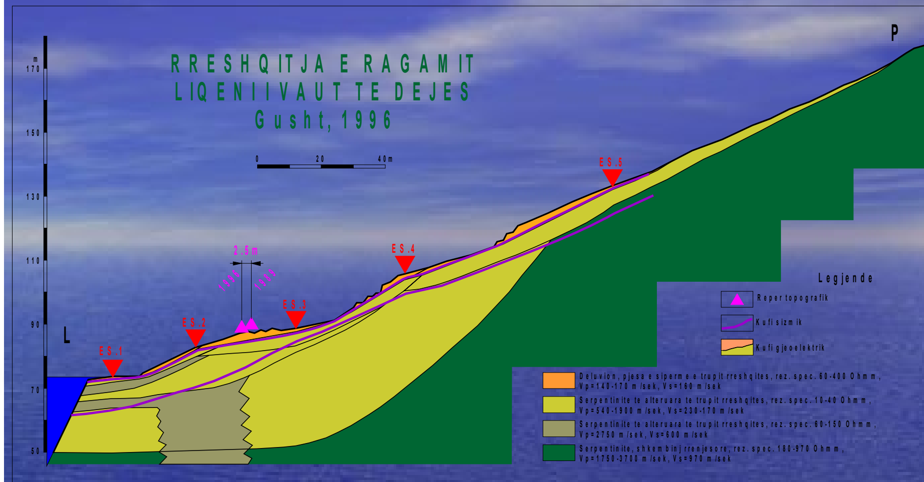
In response to the demands of time and development directions of the geophysics in the last two decades, there were worked successfully for the creation of **Engineering and Environmental Geophysics in Albania**.

For this have been worked in many fields:

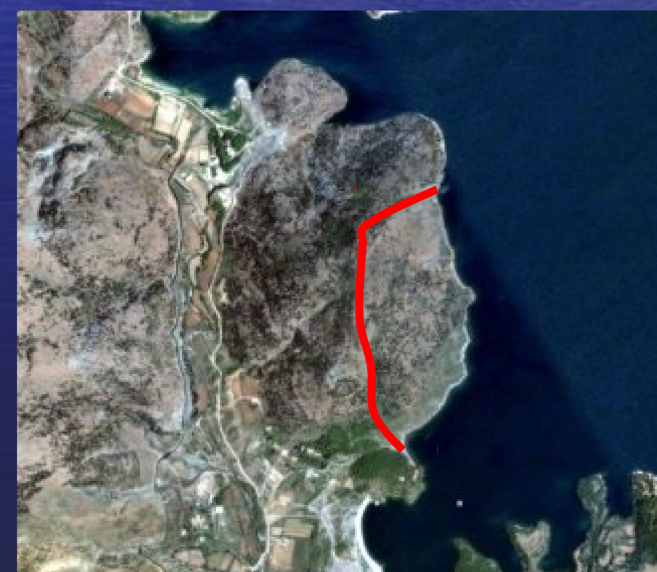
- In-situ seismic and geoelectric tomographies for dams investigation,
- the slope stability evaluation and landslides study,
- soil and bedrocks study in construction and dam sites, of highways, tunnels, etc.,
- karst areas exploration,
- quality assessment of the concrete during construction works, and in the airport runway,
- water exploration,
- study of the urban and industrial landfills,
- assessment of the environmental impacts.

Actually are taken the first positive results, first experience, as well as problems of the beginning.





Dams investigation



Landslides investigations

- Currently, the geophysical prospecting of oil and gas reservoirs, copper and chromium and other solid minerals deposits are suspended entirely by Albanian geophysical teams.
- Cessation of work and geophysical studies extremely serious consequences for future geological researches: The geological explorations remain without the modern researci methods, and turn to the thirty years of the last century level.
- With the termination of geophysical explorations, the teams will be destroyed and lost an half century of their experience, well known also from prestigious institutions of advanced countries.

Today, in Albania is important that, in addition to traditional explorations and geological-geophysical studies, based on scientific platform to take the proper development and implementation of Applied Geophysics directions in accordance with the requirements of market economy, for oil & gas and solid minerals explorations, as well as for solving engineering and environment tasks, using modern methods and surveys technology.

For the development of engineering and environmental studies are used the same methods, technologies, and equipments that are used for search of minerals. So, at the present, with exceptions when were working in the framework of European project. Albanian geophysical teams is necessary to obtain modern equipment to solve these new geological tasks, presented by today the market economy in Albania. In particular, this situation is very serious for the study of construction areas, of roads, the investigation of the hydrotechnic constructions like dams, the evaluation of the slope stability and landslides, the assessment of geological hazards, etc..

For the forming of the yang geophysicist engineers, currently the problem is re-opened of the Geophysical Branch, and the preparation and implementation of curricula and programs in accordance with the requirements of the Bologna Protocol and today technological level of the geophysical methods. Future geophysicists should be able to realized the oil & gas, and solid minerals exploration, in parallel is necessary to be able to solve also the engineering and environmental problems, applied surveys with modern technology and digital processing of data.

I want to finish our speech with a actual directions of geophysical methods application that opens new horizons for the geophysics in Albania.

Problem to be solved	Multidisciplinary approach
Air/gas emission quality monitoring	Contamination chemistry, fluid dynamics, gas radiometry/emanometry
Noise/vibrations monitoring, induced quakes control	Seismic monitoring, seismic signal processing
Geological mapping in urban areas	Sophisticated geophysical methods,remote sensing, geological mapping
Forensic/criminologic investigations	Sophisticated geophysical methods, medical/engineering ultrasonic investigations, toxicology
Lithological and geological structure, depth to bedrock or groundwater level	Geotechnics, Sophisticated geophysical methods
Cavities, caverns, mining shafts, soil sinking	Sophisticated geophysical methods, civil engineering, archaeology, history
Soil/rocks physical characteristics	Geology, geophysics, hydrogeology, hydrogeochemistry
Roads/bridges, railways, tunnels, channels, pipelines and cables detection and quality	Geophysics, geotechnics, hydrogeochemistry, microbiology, toxicology
Groundwater distribution, quality and management	Hydrogeology, hydrogeochemistry, toxicology, microbiology, fluid transport modeling, regulations in domain of ecology
Groundwater contamination	Sophisticated geophysical methods, chemistry, fluid flow modeling, regulations in domain of ecology
Leakage from landfills	Toxicology, medical statistics, geochemistry, geophysics
LNAPL transport detection and monitoring	Geophysics, civil engineering, toxicology
Public health: geochemical, factors, medical factors	Volcanology, seismology, matematical modeling, Sophisticated geophysical methods, civil engineering, geography – GIS, fluid dynamics
Safe disposal of toxic waste	Stratigraphy, paleobiology, volcanology, matematical modeling, fluid dynamics, geophysics, geography – GIS, atmosphere physics
Landslides, volcanic eruptions, earthquake forecasting, amelioration	
Sea level variations, global heating, catastrophic floods	

Thank you very much for your attention!

INTERNATIONAL CONFERENCE ON MARINE AND COASTAL ECOSYSTEMS (MarCoastEcos2012):

Increasing knowledge for a sustainable conservation and integrated management.

25 – 28 April 2012, Tirana, Albania

MORFOMETRIC CLASIFFICATION AND HYDROMORPHOLOGICAL DEVELOPMENT OF THE ALBANIAN ADRIATIC SEA COASTAL AREA

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Tirana, 2012

OBJECTIVES

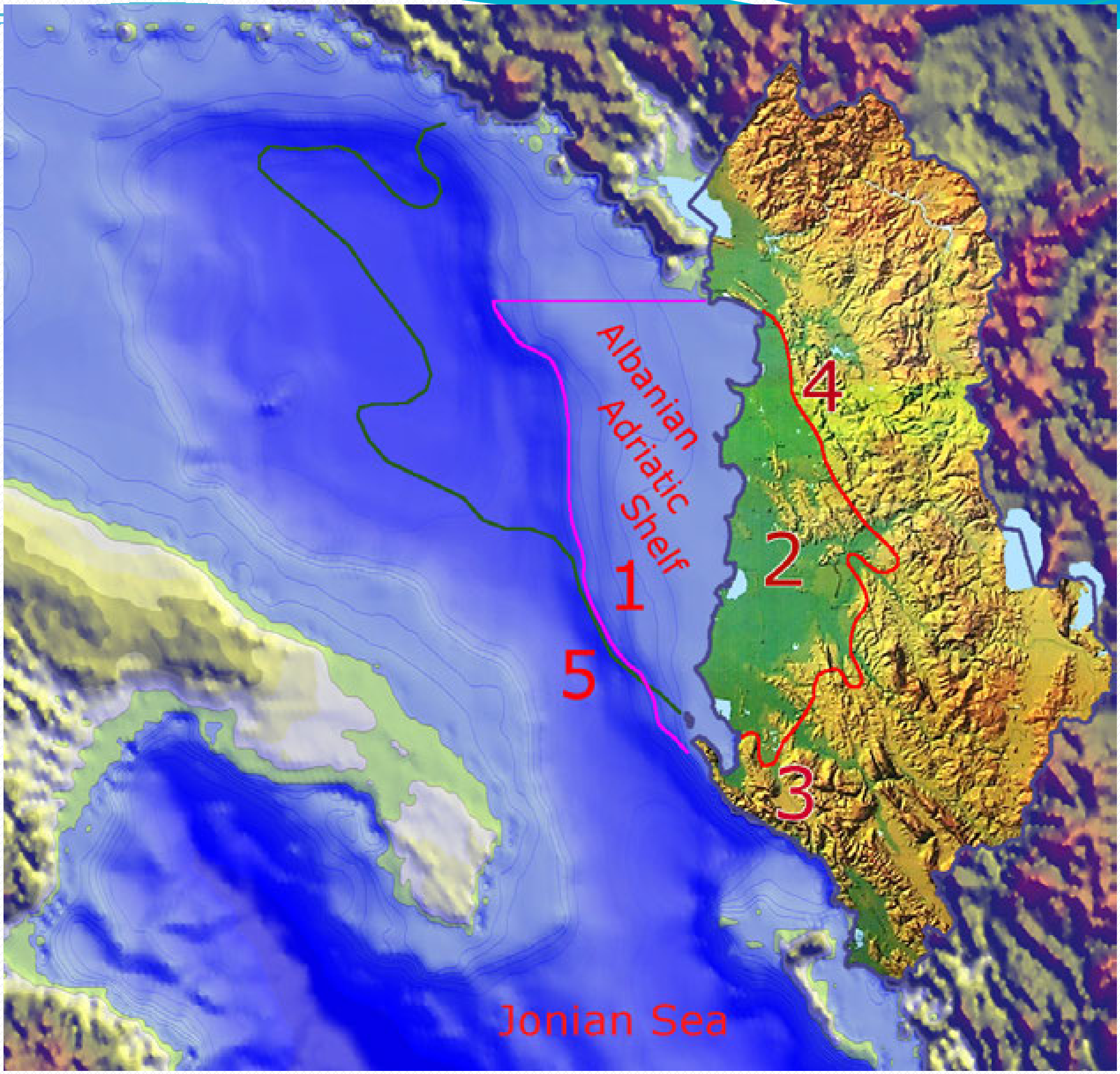
- Results of integrated hydrographical studies and offshore and onshore geological-geophysical surveys in Albanian Adriatic Littoral are presented in this paper.

  According to:

- the evaluation of the discharge regime in Albanian rivers system and its impact on the hydromorphology of Adriatic Sea,
- the river bed deformation, migration and new river mouths investigations,
- seismic and geoelectrical marine and onshore surveys,
- geological onshore mapping and underwater offshore sampling,
- boreholes and oil and gas depth wells,
- geodesic and bathymetric mapping

have ***been classified the segments which have different geomorphology with in mainland and in marine area of Albanian Adriatic Shelf.***

ALBANIAN ADRIATIC AND IONIAN SEAS COASTLINE AREA.



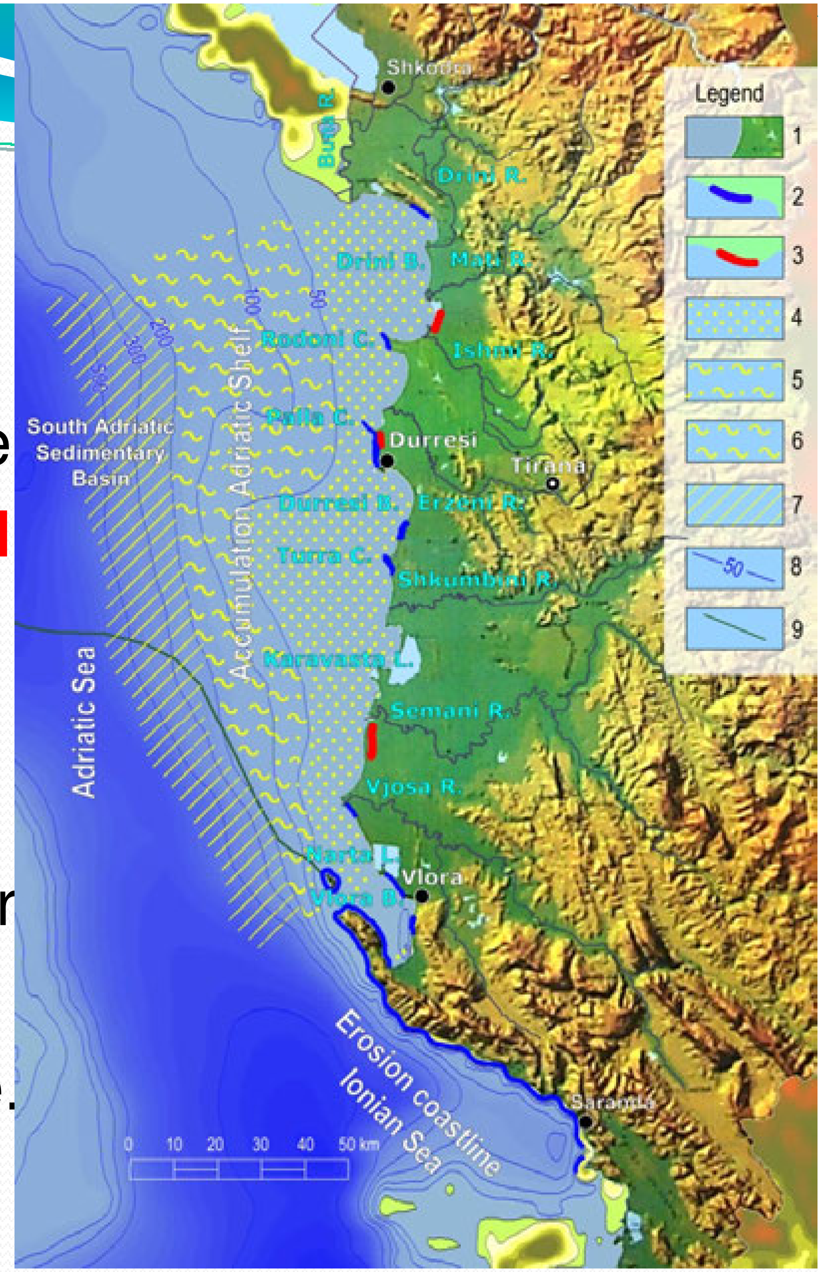
•1. Albanian Sedimentary Basin; 2- Periadriatic Depression; 3- Ionian tectonic zone; 4- Kruja (Gavrovo-Dalmatic-Montenegro) tectonic zone; 5- Apulia platform, Paksos zone

Geomorphological Scheme of Albanian Adriatic and Ionian Seas coastline.

Adriatic coastal line from southern city up to Shëngjini Bay, in the north, have

- **The marine accumulation flattened littoral**,
- **The marine erosion coast**, and
- **The submerged areas**, where
- is observed marine ingression towar

In some areas there is cliffed coastline.



1 Accumulative coastline; 2- Erosion coastline; 3- Submerged littoral zone; 4- Shoal shelf area with sand deposits; 5- Flat shelf area with sandy-silt deposits; 6- Inclined shelf area with muddy silt and deposits; 7- Continental slope with argillaceous sediments; 8- Isobaths; 9-Western flank of the South Adriatic Sedimentary Basin.

Flattened Albanian Adriatic Litoral of Western Albania

Adriatic coastline is lies over the Neogene Peri-Adriatic Depression, covered by Quaternary deposits, in western plain areas of Albania.

Flattened accumulative coast is general characteristic of this coastline.
There are also some hilly marine caps with cliffed coast.
The caps are located in the sectors where the Neogene structure of the Peri-Adriatic Depression are abrupt by coastline and continues in the Adriatic Sea,
There are also old river deltas or mouths and submarine coastal bar.

Adriatic coastline is divided in different characteristics zones:

Segment 1
Mouth of Buna River at the north to Rodoni Cap coastline.

This unit has a length about 60 km and consists for almost 90% of beaches fed by fluvial imputes. The remaining 10% is clifts. Four rivers outflow within this area: from north to south Buna, Drini, Mati and Ishmi rivers All together they discharge on average

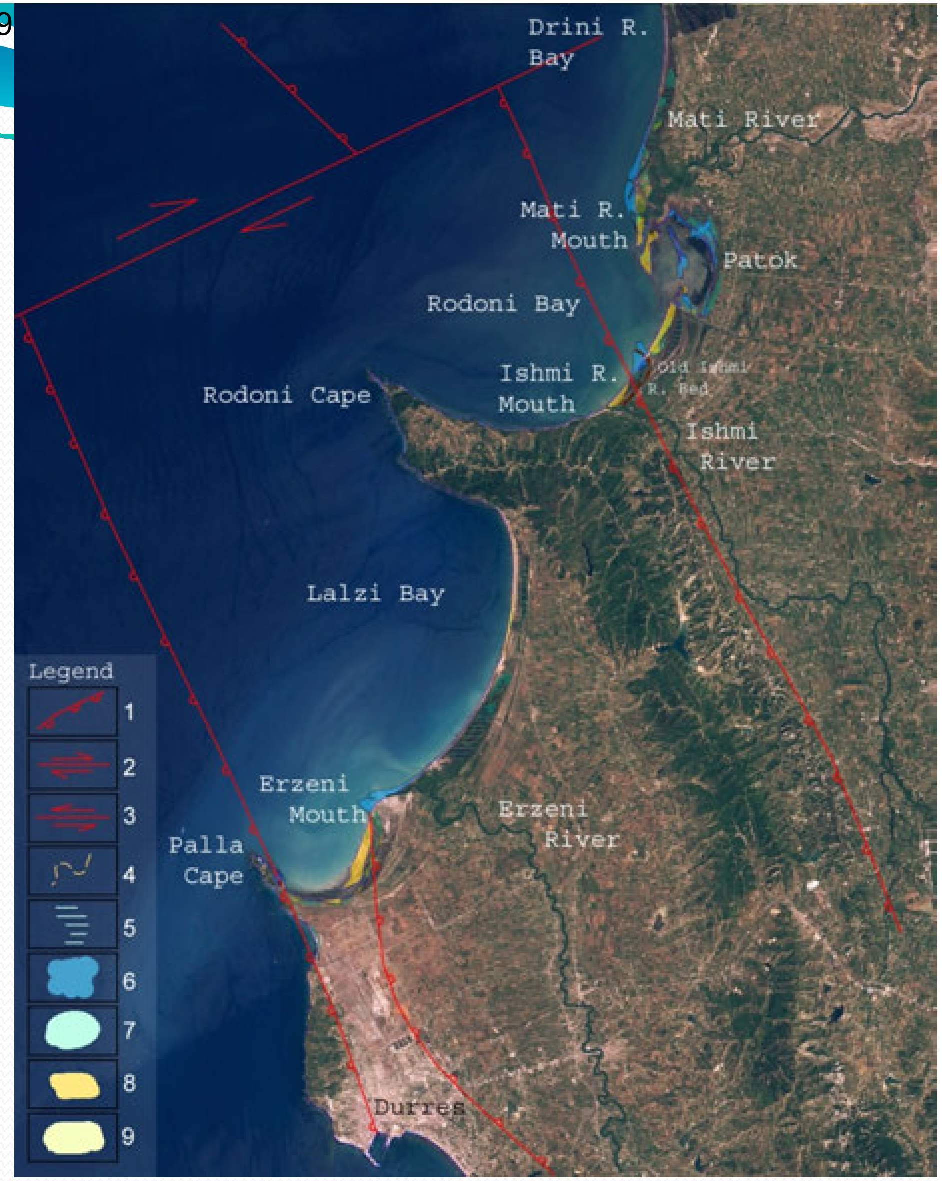
Discharge of the solid material by Mati River in Drini Bay, Albanian Adriatic Coastline.

796 m^3/sec of water. The total solid load of the last three rivers is about $21,680x110^3$ tons/year.

Intensive change dynamics were observed in this area.

Geomorphological Evolution view of the Drini -Durrësi Bays coastline in the Albanian Adriatic Littoral

This littoral is characterized by presence of the different Quaternary deposits genetic types.
Marine Quaternary littoral deposits, presented by fine, medium, and Coarse gray—white, gray-yellow sand, silty clay and mud interbeds.
Present days micro and macrofauna of seawaters comes across everywhere.
Very beautiful sandy beaches are extended in Drini, Lalezi, bays.



1- Active reverse fault & thrust; 2- Dextral strike-slip; 3- Sinistral strike-slip; 4- Old Mati River bed; 5- Wetlands; 6- Erosion and marine ingression; 7- Lagoon extension; 8- Coastal deposition; 9- Lagoon surface diminishing. (*Neotectonics, active reverse faults & thrusts, (after Aliaj Sh. et al. 2000)*)

General Geomorphological Evolution view of the Vjosa River Mouth- Mati River

Patoku beach in the southern side of the Shengjini Bay represent submerged areas within accumulative coastline. Submerged process is caused by the neotectonics activity, consequently there are observed a marine transgression.

The same phenomena is observed also in Semani beach at central segment of the Albanian Adriatic Littoral.

Patoku submerged Beach

Semani submerged Beach

Mouths in the Albanian Adriatic Littoral. (Geologic Map of Albania, at scale 1:200.000, 1983, the neotectonics active reverse faults & thrusts after

Aliaj Sh. et al. 2000).

1- Alluvium Quaternary Deposits; 2- Marine Quaternary deposits; 3- Boggy Quaternary Deposits; 4- Pliocene Rogozhina conglomerate suite; 5- Pliocene Helmësi suite;

6- Neotectonics active reverse fault & thrust; 7- Coastal erosion; 8- Accumulative area; 9- Submerged littoral area; 10- Marine Electrical Sounding center.

Segment II

Rodoni Cap, Durrësi Bay up to Shkumbin River mouth coastline.

Cape Pallës, Cape Selitës, Lalëzi Bay, Durrësi Bay and Shkumbini River mouth are main sectors of this littoral area. Lalëzi Bay has a length of coastal line of 32 km, and 65% consists of sandy beaches fed by the sediment load of Erzeni River. The remaining 35% consists of rocky cliffs. Durrësi Bay has a length of 35 km from Pallës Cap to the Selitës Cap. Main part of the bay littoral, about the 54% of their length, by sandy beaches is presented. Frequently, with dune ridges, vegetate by pine trees, there are extended. Sediment inputs in to the bay are provided by Darçi River and from beach and cliff erosion.

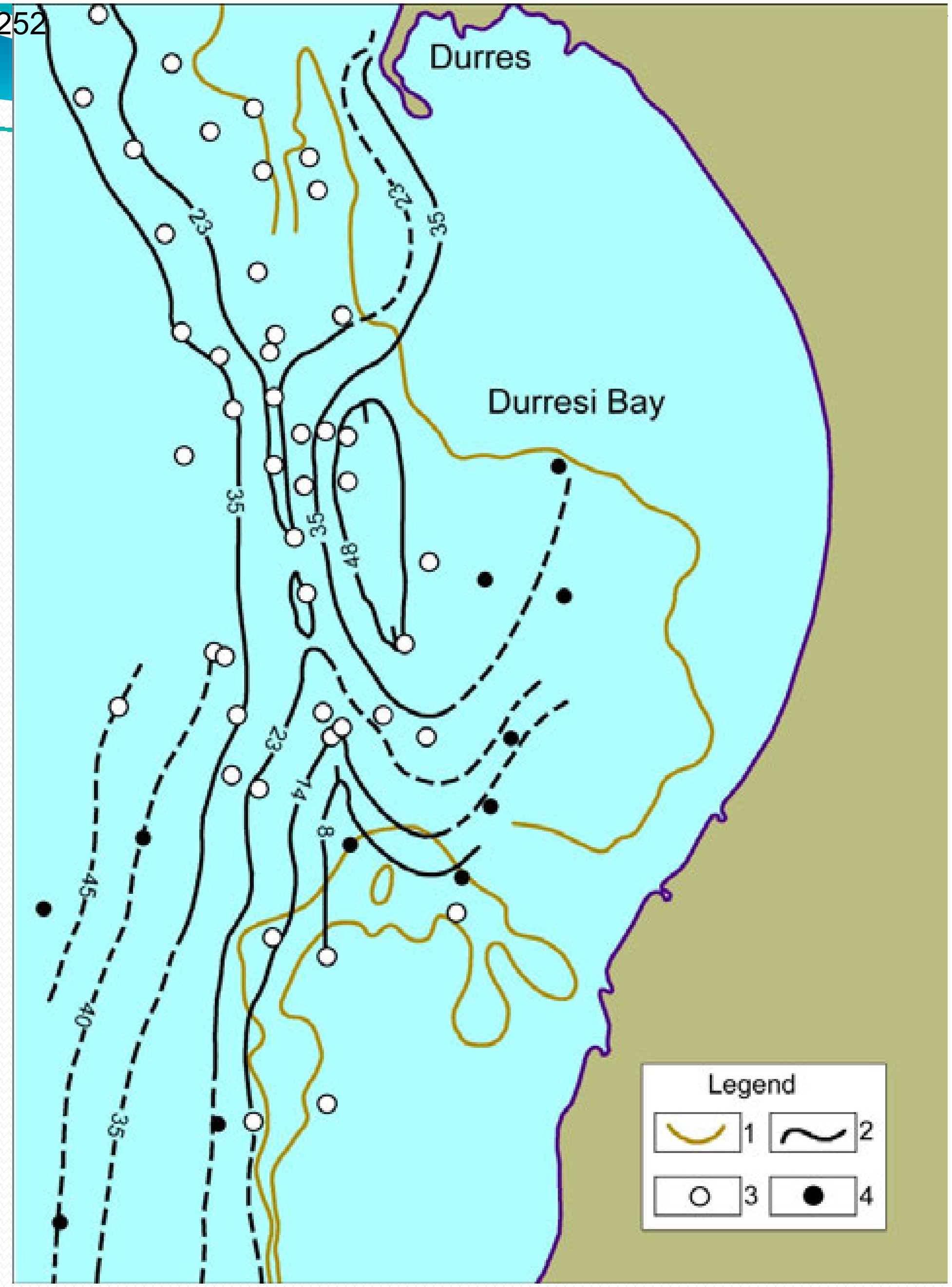
Accumulative Coastline in Durres.

Heavy and rare mineral placers in acummulative coastline, Lalezi Bay.

Thickness Map of Quaternary Deposits in Durrësi Bay.

•The maximal thickness of the Marine Quaternary deposits is observed at the central part of the marine bays, according to the marine electrical soundings and mapping boreholes data.

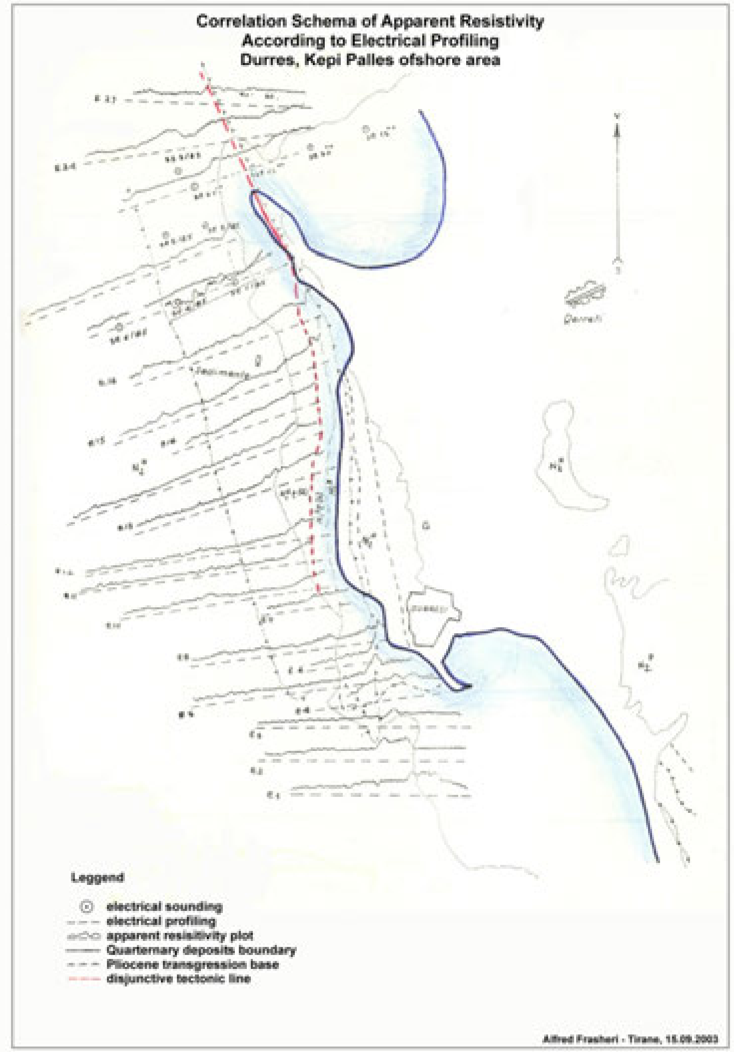
•In the Durresi Bay. The maximal thickness is 48m at the central zone of the bay, about 6 km south of the Durrësi city



1.Boundary of distribution of sand-argillaceous sediments; 2- Contours of the Quaternary deposits thickness; 3- Marine mapping boreholes; 4- Marine electrical sounding centers.

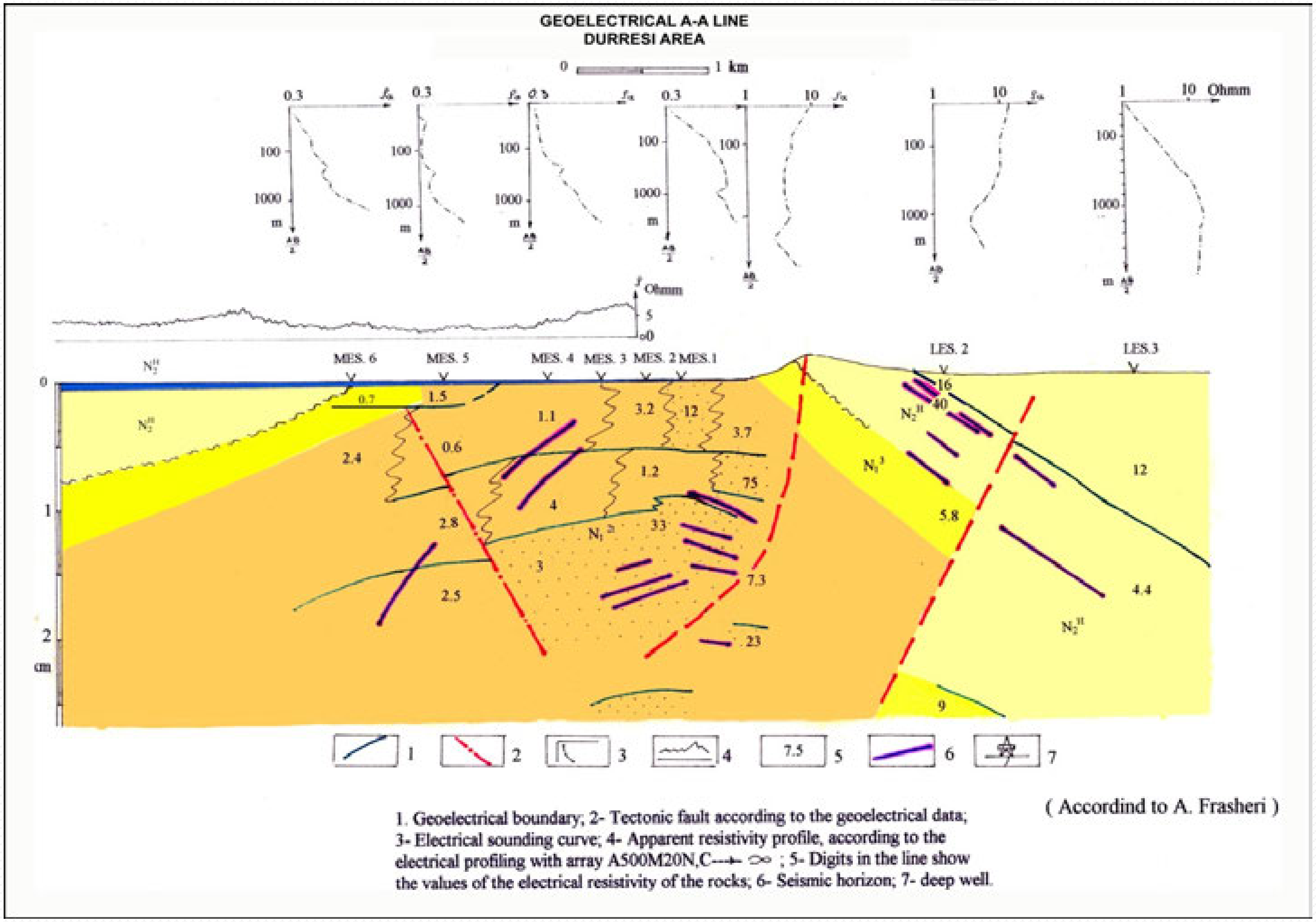
Erosive coast line in Durresi anticline, Currila sector

Durrësi–Pallë Cape area is one most typical erosive segment of the Albanian Adriatic littoral. Durrës-Kepi Pallës coastline is extended along the western flank of the Miocene-Pliocene molasses anticline.
The sea-floor sandy belt, of 2.5 km width, which lies parallel to the coastline in the shoal zone. According to the integrated marine geological-geoelectrical surveys there are observed, submarine Miocene-Pliocene eroded bedrock banks



Correlative Schema of Apparent Resistivity according to the Marine Electrical Profiling, offshore erosive littoral at Durrësi-Kepi Pallës area.

Geoelectrical Line, erosive littoral at Durrës-Kepi Pallës area.



1- Geoelectrical boundary; 2- Tectonic fault according to the geoelectrical data; 3- Electrical sounding curve; 4- Apparent resistivity profile, according to the electrical profiling with array A500M20N, C→∞; 5- Digits in the line show the electrical resistivity values od the rocks; 6- Seismic reflector.

Segment III

Shkumbin-Seman-Vjosa rivers mouths up to Zvërneci hills coastline

Is located in southern part of Central Albania, and have 40 km length. It expands in the western part of Ardenica and Divjaka hills. Karavasta Bay and Karavasta Lagoon are also part of this littoral area. From the geological viewpoint, this territory represents a new soil, constituted at the end of Pliocene and during Quaternary. The coastline in this region has a very intensive dynamics.

Present time shore sand knolls have a length up to 4-5 km, width 35-80 m and some meters highs. At the northern bays, the coarse sand is predominated. This sand belt are composed

by two or three parallel onshore dunes:

the first dune is extended directly at the water

line, the second at the distance 90-100 m and

the third dune 150-200 m.

Photo: Sandy burried dunnes in Semani acummulative coastline

Geomorphologic view of Shkumbini River-Vjosa River mouths coastline

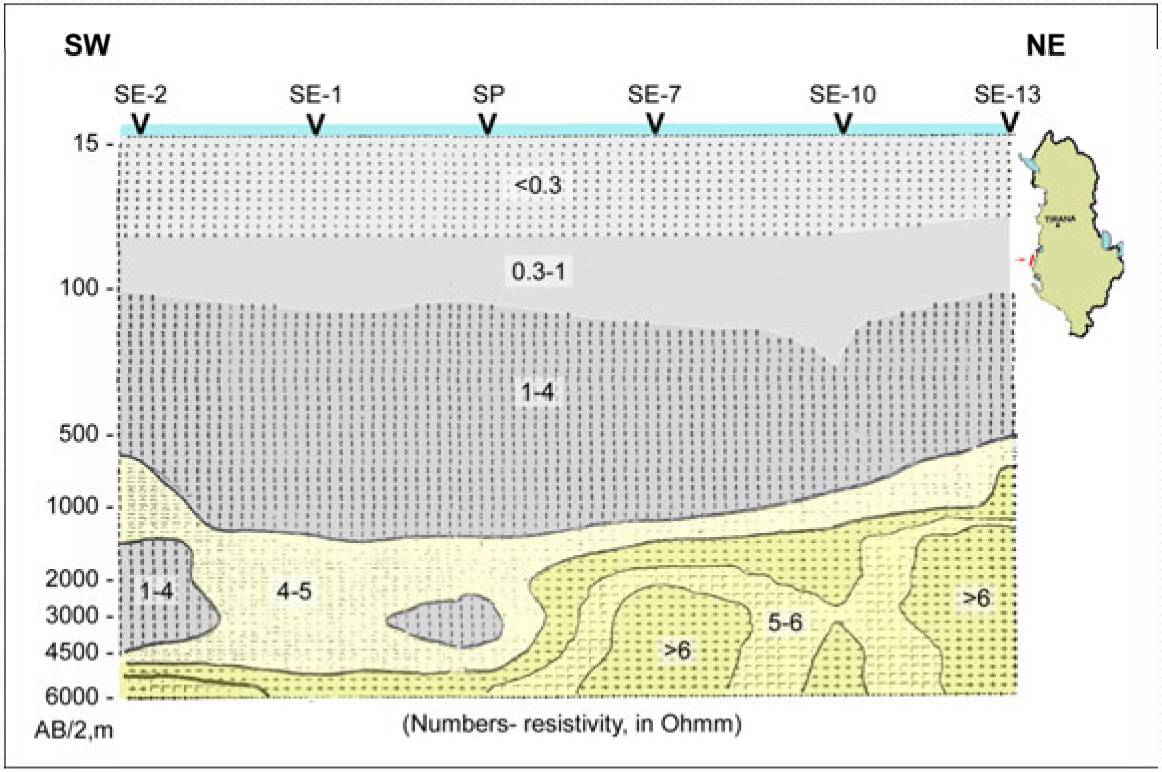
There are observed the re-activation of the disjunctive tectonics at the littoral area Seman beach - Karavasta Lagoon -Shkumbini River mouth, in the both flanks of the Semani asymmetric anticline structure the disjunctive tectonics, with small amplitudes of 200-400m, are re-activated.

1.Active reverse fault & thrust; 2- Dextral strike-slip; 3- Sinistral strike-slip; 4- Old Shkumbini River bed; 5- Coastal deposition with predecessor erosion; 6- Coastal deposition; 7- Coastal erosion; 8- Submerged littoral area. *Neotectonics active reverse faults & thrusts (after Aliaj Sh. et al. 2000).*

. Marine Electrical Resistivity Tomography Line, Semani Adriatic Shelf.

According to the marine electrical resistivity tomography, performed by marine electrical soundings, the morphology of the marine Quaternary loose deposits has a horizontal layering at the western side of the Semani beach. In south and east northern sides of the geoelectrical line is observed reversed fault impact.

Consequently, the Semani sandy beach, which is located at western side of this fault, in the submerged process, is found, from 4 km of south of the Semani River Mouth up to Semani Beach area, in the about 10 km long segment .



Segment IV

Vlora *Bay*

Is represented southeastern edge of Otranto Strait.

The *Upper* Cretaceous- Triassic limestone mountains are encircled southwestern and southeastern shores of the bay. In the north, the mountain chain is continued with Neogene's deposits hills.

Limestone coast of the Adriatic Sea in Vlora Bay is generally abrupt. At the northwestern direction of the Vlora City, there is a coastline of the Albanian Adriatic Shelf. Configuration the Vlora Bay has started to form from the Pliocene age, when the molasses of the Panaja Hills have been outcropped at surface.

Actually, Later Quaternary Marine deposits (Q_4^m) are created the present Vlora Bay. Offshore these deposits (Q_4^m), according to the marine electrical soundings and boreholes, have 190 m thick.

General Evolution view of the Vlora Bay

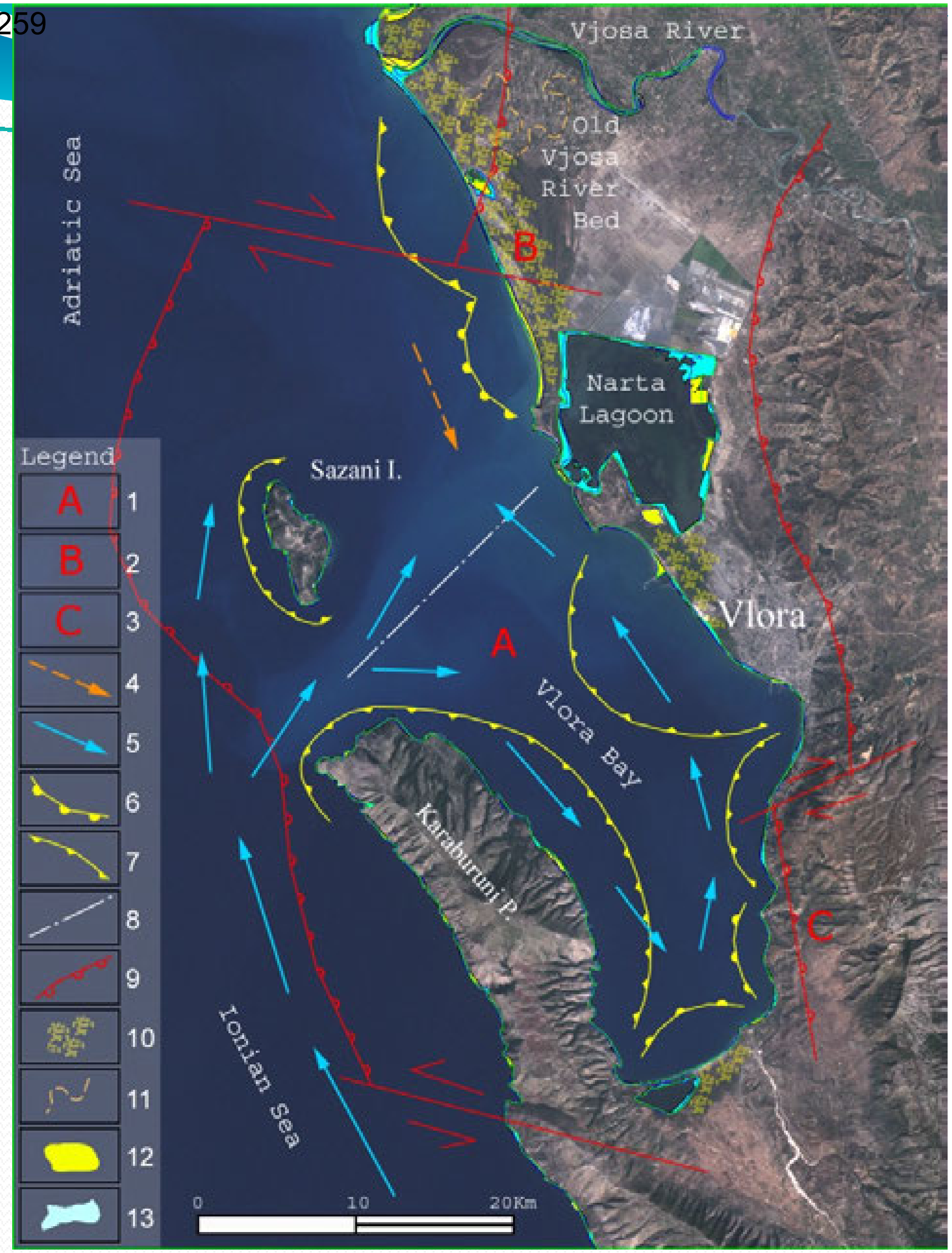
Vlora Bay has a length of 36 km and 10 km width.

The maximal depth of this bay is 57 m. The coastline of Vlora Bay-Vjosa River Mouth area has continuously modified its configuration by sedimentation of alluvium transported by Vjosa River water and the swell of the Adriatic Sea.

The coastal area is characterized by prevalence of winds blowing from the NW direction with a maximal speed 35-45 m/sec.

The tidal range in this part of Adriatic Sea is low, reaching a maximum of 30-50 cm.

The wave action is characterized by calm in 35% of the cases, by wave with a higher of less than 0.5 m in 20% of cases and waves higher than 2.00 m in 3% of cases.

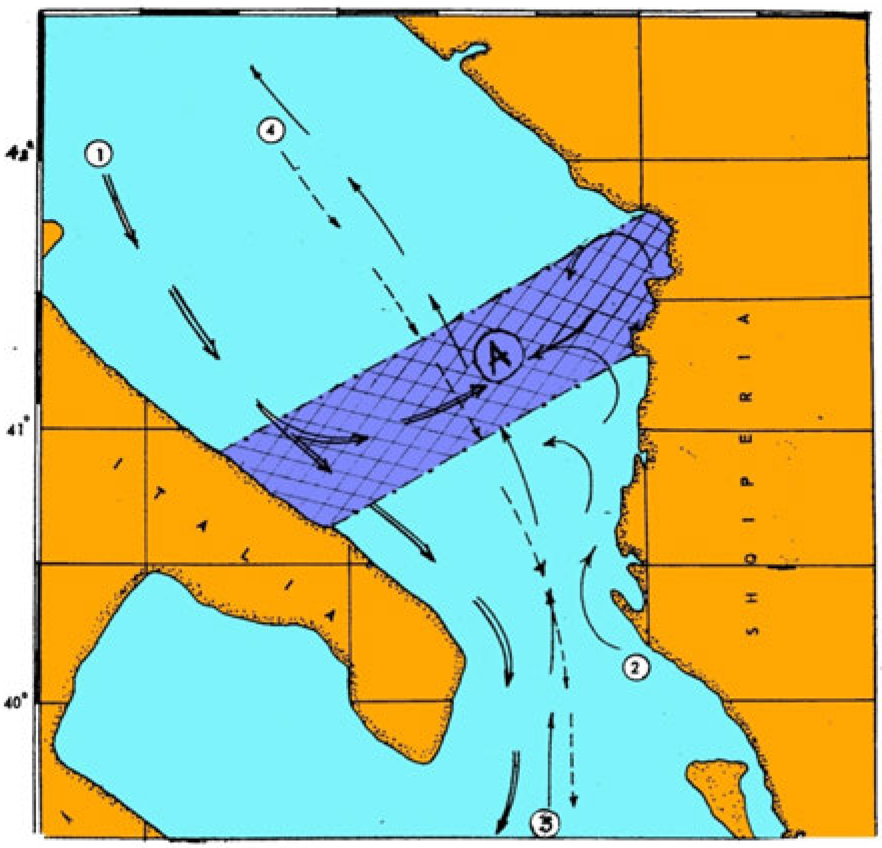


1- Marine shoal with sand deposits; 2- Littoral with sand beaches; 3- Rocky coastline; 4- Alluvium flow; 5- Marine current direction; 6- Accumulation area; 7- Erosion area; 8- Southern edge of the sediment replacement; 9- Active reverse fault & thrust; 10- Sand; 11- Old Vjosa River bed; 12- Filling coastline; 13- Erosion coastline.

A correlation between geological setting Adriatic Albanian Shelf and sea hydrology

- Two Albanian Oceanographic Expedition have presented data, which have argument that the total discharge of the Albanian rivers system in the Adriatic and Ionian Seas have a minimal discharge is 700-800 m^3/s during the hydrological dry years of low precipitation and maximal values 1900-2200 m^3/s during the hydrological wet years of high precipitation.

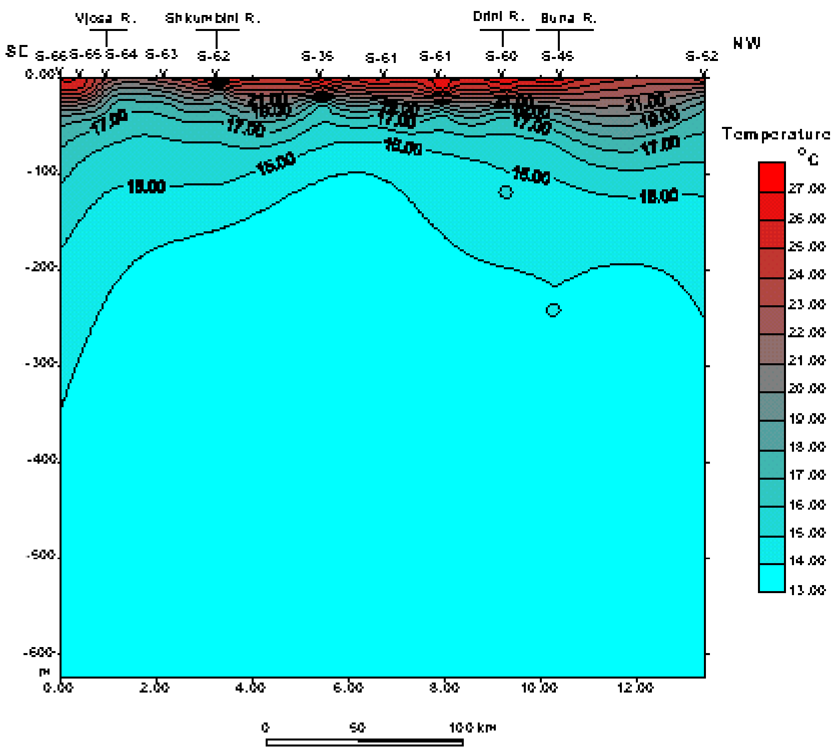
The oceanographically situation of the wet years 1963-1964 has been characterized by formation of "The Bridge" of low salt content and density, and higher temperatures of the seawaters in the Adriatic Sea. A higher surface water temperature in the Drini Bay is confirmed also by satellite observations, with a higher temperature of 3-4^{o}C.

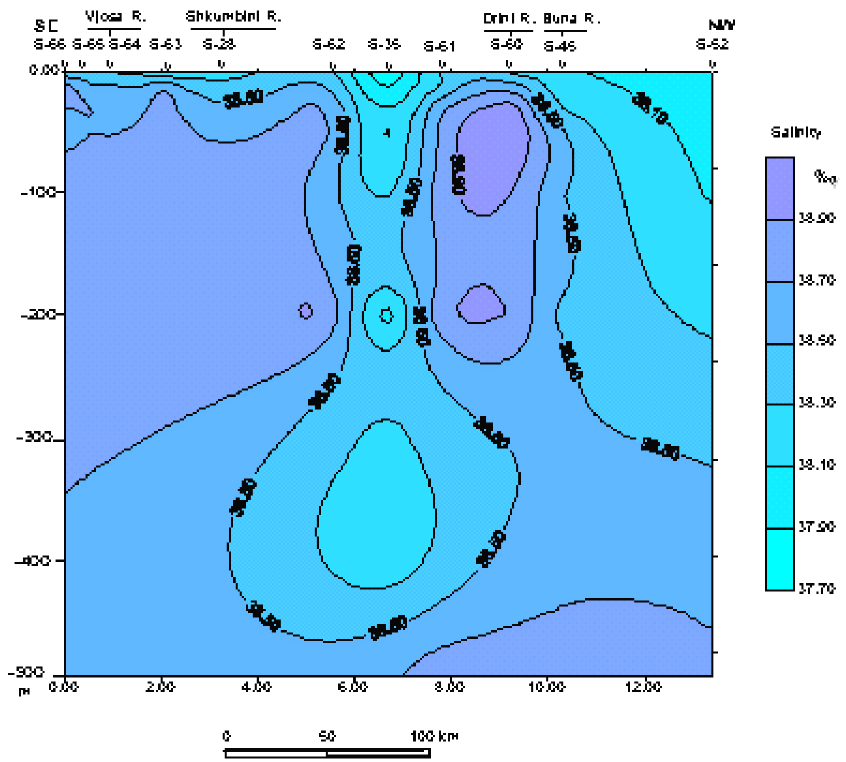


1. Adriatic Deep Water Mass; 2. Eastern Adriaric Superficial Water mass;
2. 3. Intermediate Levantine Water mass; 4. Northern Adriatic Water mass.

Vertical temperature section

Vertical salinity section .





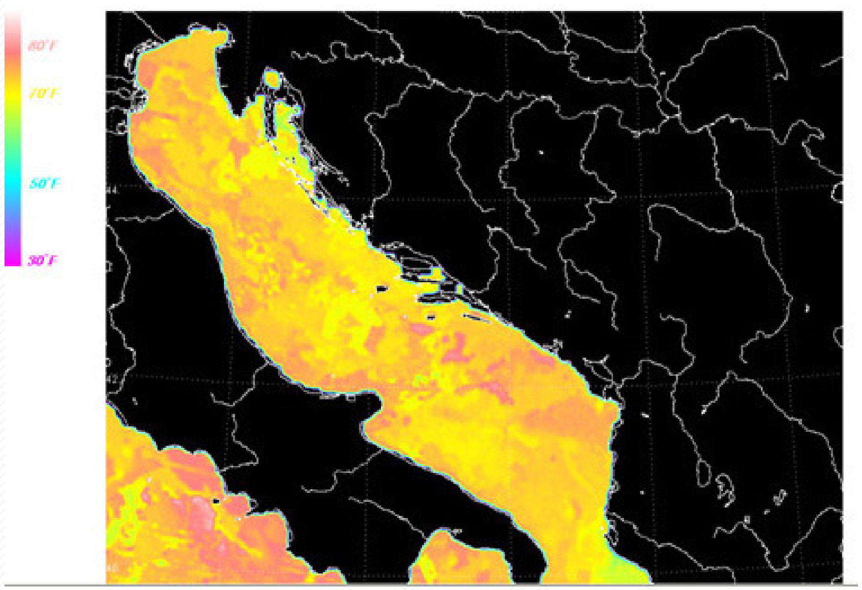
Adriatic Sea, wet hydrographical year 1963

Adriatic Sea, wet hydrographical year 1963.

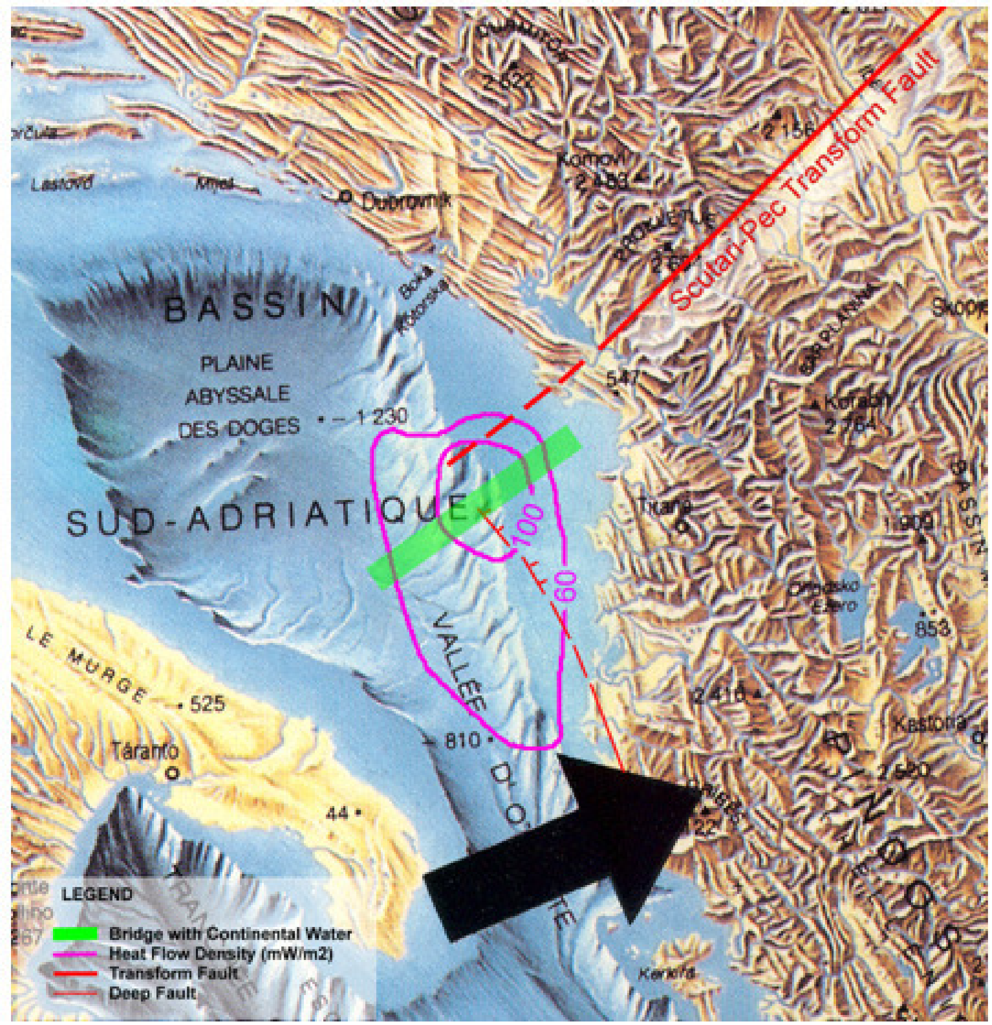
- . The "Bridge”, includes surface water layer, and the Levant Intermediate Water (LIW) up to 600 m. depth. This phenomenon has a complex and an important influence on many dynamics aspects of the formation Adriatic Deep Water (ADW), and the monitoring mechanism of water into Otranto Street.

Adriatic Heat Flow Density Anomaly

This “Bridge” is correlated with the heat flow density anomaly at the sea bottom (Geothermal Atlas of Europe, 1992). The “Bridge” direction is corresponds also with the prolongation into Adriatic Sea Albanian Shelf of well-known Scutary-Pec regional tectonic transversal over the Albanides, which is outcropped in Albanian mainland, with a SW dextral strike-slip direction.



Adriatic Sea Surface Temperature, restore from satellite data 19.08.2005 (Sputnik SST, 1999 SMIS IKI RAN, Moscow)



Climate change

Ground surface history after geothermal inversion and meteorological data were observed a climate worming for about 1°C during the first half of XX century. Thirty quart of this century has been characterized by a cooling for 0.6°C. Later, up to present a worming for 1.2oC is observed. The warming period in Albania is accompanied with changes of the rainfall regime, wind speed and wetness. There are observed a decreasing of the total year rainfall quantity, for about 200-400 mm. This warming is part of the global Earth warming during the second half of XX century. These climate changes have their impact on country water system, on and water resources, and in the erosion processes .

Inland water resources change has its impact on the hydrographic regime in Albania.

These climate changes have their impact on country water system:

- on and water resources,
- on the erosion processes, and
- on the hydrographic regime of the Adriatic Sea.

Conclusions

- Albanian littoral has two major units: accumulative Adriatic coastline and erosive Ionian seaside.
- Albanian Adriatic coastline has an intensive change and continuously modifying its shape.
- Submerged process, caused by neotectonic activity, is observed in some sectors within accumulative Adriatic coastline.
- The climate at coastal plane region of Western of Albania has a warming of 0.6 K occurred, from last quarter of 19th until present-day. These climate changes have their impact on country water system, on and water resources, on the erosion processes, and on the hydrographic regime of the Adriatic Sea.
- The oceanographically situation in the Adriatic Sea is characterized by the formation of "The bridge" with continental water in the Adriatic Sea. "The bridge" is closely linked with the intensity of the Albanian rivers flow to the sea.

Thank You for your attention!

THERMAL AND MINERAL WATERS OF ALBANIA AND THE PLATFORM FOR THEIR INTEGRATED AND CASCADE USE

Romeo Eftimi*, Alfred Frashëri

1. Summary

Based on geological conditions, as well as on the hydrochemical and thermal characteristics, four provinces of thermomineral waters are has been distinguished in Albania. In the paper, for each province are described geological-structural, thermal and hydrochemical characteristics. Most important province in terms of the thermomineral underground water resources results Kruja province, very reach on high temperature H_2S groundwater. The platform for the integrated and cascade use of these thermomineral waters represent an important part of the study.

.2 Introduction

In Albania the presence of some high mountain chains and of active fault systems favors the rise of deep waters that discharge at the surface as thermomineral springs. Some important thermomineral springs are widely used for their excellent curative properties like those of well known spa of Peshkopia, Llixha Elbasan and Leskoviku. The results of some deep wells confirm, also the presence of important thermomineral water resources particularly in the Adriatic basin. Some good chemical analyses has been performed for the most important thermomineral springs, while for deep wells only some general chemical analyses have been performed during the oil prospecting. The goal of this paper is to summaries all the existing data and to estimate the thermomineral groundwater, as part of deep regional groundwater flow system and thermal springs as their discharge features.

3. Geological setting of the Albanides

The Albanides represent the assemblage of the geological structures in the territory of Albania, as a part of southern branch of the Mediterranean Alpine Belt. Two major peleogeographic domains consists the Albanides: the Internal, and the External Albanides (Fig. 1). The earth crust is characterized by a system of longitudinal fractures in NW - SE direction and transversal faults that touch even the mantle. The thickness of Albanian sedimentary basin is 8-9 km in Adriatic seashore and reaches up to 15 km in northwestern regions of Albania.

The tectonic zones of the *Internal Albanides* extending in eastern part of Albania are: 1. *Korabi Zone*, which continues in Golia Zone in Dinarides and Pelagonian Zone in Hellenides, is represented generally by terrigene and metamorphic limestone of Paleozoic ages. *2. Mirdita Zone* continues as Serbian Zone in Dinarides and Subpelagonian Zone in Hellenides. The lower tectonic unit of Mirdita Zone is presented by the overthrusted ophiolitic belt thickness 2-14 km. In Mirdita zone lies also Korça-Librazhd and Burreli depressions, filled by the Neogene molasses. 3. *Gashi Zone* continues as the Durmitori Zone of the Dinarides. The representative formations there are metamorphic terrigene, limestone, and volcanic rocks.

The tectonic zones of the *External Albanides* extending in western part of Albania are: 1. *Alps Zone* is analogue to High Karst in Dinarides and Parnas Zone in Hellenides. The lower part of this zone consists of Permian sandstone and the conglomerate while the upper part of the zone consists mainly of Mesozoic limestone forming some monoclines, combined with smaller anticlines. 2. *Krasta-Cukali Zone* continues in Budva Zone of the Dinarides and Pindos Zone in Hellenides. Krasta subzone consist a narrow belt filled with flysch formations and represents an intermediately zone between the Internal and External Albanides. 3. *Kruja Zone* continues with Dalmate Zone in Dinarides and in the south by Gavrova Zone of the Hellenides. Generally, the Cretaceous-Eocene limestone and Paleogene flysch formation, covered by Neogene formations are representative rock of this zone. 4. *Ionian Zone* continues beyond borders in Greece at south-western part of Albania. The Permian-Triassic evaporates, the oldest rocks of this zone, are covered by thick deposits of Mesozoic-Paleogene limestone. Carbonate formations are covered by Paleogenic flysch and of Neogene deposits. They

form three anticline belts often cut by longitudinal tectonic faults in western structures flanks. 5. Sazani zone is the continuation of Apulian platform. A thick Cretaceous-Eocene limestone and dolomite section, trangressively covered by marly deposits of Burdigalian builds this zone. 6. *Preadriatic Depression* covers the Ionian, Sazani and partly Kruja tectonic zones. This depression is filled with middle Miocene and Pliocene molasses, which are mainly covered by Quaternary deposits. Molasses consist of a sandy-clay mega-sequence. The Depression plunge to north-west, to Adriatic Sea and the molasses thickness increases up to 5000 m. Sandstone-clay deposits of Serravalian are placed trangressively over the oldest ones, up to the limestone, creating a two-stages structure.

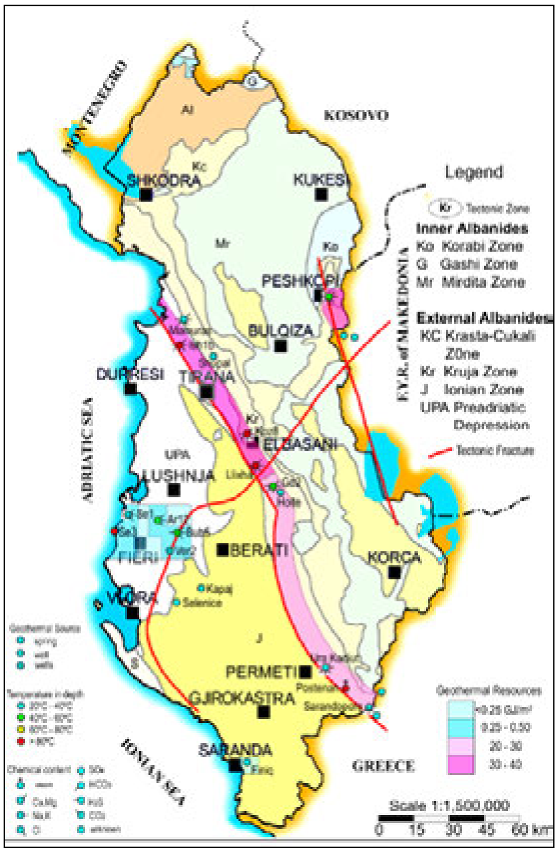


Fig. 1: Geothermal resources of Albania

Fig. 2: Geothermal Kozani-8 deep well

4. Mineral water basins

Although Albania is a small country, his regional hydrogeological picture is very heterogeneous. The complex geological-structural and geomorphologic conditions of Albania have resulted in aquifer's heterogeneity concerning their resources, hydrodynamics and hydro-chemical characteristics (Eftimi 2010). The thermal and mineral waters of Albania are located in four thermo-mineral provinces: a) Peshkopi province; b) Kruja province; c) Preadriatic basin province, and d) South Ionian province.

Peshkopi province represents the central part of Korab zone which is characterized by the presence of two tectonic windows where gypsum dome structures outcrop. Two important sulfur thermo-mineral springs known as Peshkopia spa, appear at south western tectonic contact of gypsum with surrounding Paleogene flysch formations (Table 1). The formation of the springs is related to the deep fault developed along the Black Drin River. The thermal waters are of sulfate-calcium type, the temperature varies about 35° C to 43.5° C and the upward flow of the springs is about 13 l/s.

Kruja province is most interesting in terms of thermomineral waters in Albania. In the northern part of this province is developed the Tirana artesian basin hosting two deep aquifers containing thermo-mineral waters: a) the aquifer of Mesozoic-Paleogene carbonate rocks related to some deep anticline structures, and b) the aquifer of Neogene molasses rocks. Many deep oil wells have tapped the aquifer of carbonate rocks, but among them the most important is Ishmi-1/b. The water temperature is 60° C, the water chemical type is Cl-Na and the H_2S gas content is more than 1000 mg/l (Table 1). The aquifer of molasses contains mediocre water quantities with the temperature usually lower than 30° C. Kruja province hosts some big thermomineral springs like Uji Bardhe-Mamuras, Llixha and Hidraj near Elbasan, Holta, Langarica and Leskoviku. Only the Uji Bardhe spring, which temperature is about 22.5° C, is of Cl-Na type; the other above mentioned springs and wells have temperatures varying from 24.0° C to 58.0° C and the waters are characterized by the high content of SO_4 ion and H_2S (Table 1). A particular geothermal phenomenon is the Postenan steam spring issuing from a tectonic fault crossing the Postenan limestone structure. Some deep thermo-mineral water wells, like deep well Kozan-8 free flowing about 10.3 l/s with a temperature 65.5°C (Fig. 2) are located in province, also. The groundwater of Kruja province are widely used for their excellent curative properties, particularly those of well known Llixha and Hidraj spars, as well as Loskoviku spring. Identified resources of Kruja geothermal province in carbonate reservoirs are $5.9x10^8$-$5.1x10^9$ GJ.

Preadriatic basin province hydrogeologicaly represent an artesian basin. In this basin three aquifers are identified: a) the deep aquifer of carbonate rocks; b) the intermediate aquifer of sandstone Neogene molasses, and c) the upper aquifer of Pliocene sandstone-conglomerate formations. The evidences about the groundwater of the deep carbonate rocks aquifer confirm the presence of high temperature and high mineralized of Cl-Na type groundwater. Some oil wells have free flowed high temperature and high mineralized water from Neogene molasses aquifer. Particularly important are the free flowing thermomineral water from the deep wells of Ardenica and Seman structures. The groundwater temperature at surface of Ardenica structure is about 32° C; the total mineralization varies about 38-55 g/l, and the chemical type is Cl-Na. In the groundwater of Seman structure these components are accordingly 67-83° C, about 20 g/l and the chemical type is also Cl-Na. The thermomineral waters of Adriatic basin province are rich also in CH_4 gas.

South Ionian province is the widest geothermal province of Albania, but not the richest. This province consists of some carbonate anticline, and some syncline chains filled mainly with flysch formations, dipping to the north-west under the Preadriatic basin. In this province is not known the presence of thermomineral springs. From the carbonate rocks, only big fresh water spring issue. Some deep wells have free flowing high temperature and highly mineralized groundwater. The well Grekan-4, situated near the Dumre gypsum dome, at the depth about 1200 m fountain the groundwater with temperature 35° C, mineralization about 325 g/l, and brome content of about 768 mg/l; the last parameters being the highest measured in the groundwater of Albania. Some deep wells drilled in Delvina syncline, in South Albania, have fountain also high mineralized groundwater of Cl-Na type.

Thermal springs and deep wells in Albania

Table 1

Spring (s) or well (w)	Province	Discharge l/s	Temperature ° C	Mineralization g/l	H_2S mg/l	Br mg/l	J mg/l	Chemical type
Llixha, Peshkopi - s	Peshkopi	23	35-43.5	3.5-4.0	50	2.1	0.6	SO_4-Ca
Uji Bardhe - s	Kruja	20-100	18.5-22.5	5.0-6.0	350	-	-	Cl-Na
Llixha, Elbasan - s	Kruja	28	46-58	6.8	408	5.5	1.1	Cl-SO_4-Na-Ca
Holta - s	Kruja	50-70	24.1	2.2	?	?	?	SO_4-Mg-Ca
Langarica - s	Kruja	70-150	24-30	1.2-1.6	2.0-5.8	-	-	Cl-Na-Ca
Leskoviku - s	Kruja	15	25.6-26.7	1.0	2.2-7.0	-	-	Cl-Na-Ca
Ishmi-1 - w	Kruja	3.5	57	12.6	1220	-	-	Cl-Na
Kozan-8 – w	Kruja	10.3	65.5	4.1	?	-	-	Cl-SO_4-Ca-Na
Ardenica 12 –w	Adriatic basin	18.0	32.0	53.6	?	109.7	21.2	Cl-Na
Seman-7 - w	Adriatic basin	30.0	67.0	20.7	?	25.0	30.0	Cl-Na

5. Geothermal regime

Earth crust setting of the Albanides conditioned the space distribution of the geothermal field and energy. (Frashëri et al. 2004). The gradient values vary from 15-21.3 mK/m in Preadriatic Depression. According to the modeling results, deeper than 20 km are observed decreasing gradient. The change of the gradient coincides with the top of the crystal basement. In the ophiolitic belt, the geothermal gradient reaches a value up to 36 mK/m. The maximal value of the Heat Flow Density is 42 mW/m^2 in the External Albanides. At the eastern part of Albania, the heat flow density values are up to 60 mW/m^2. Increasing of the heat flow over the ophiolitic belt, are linked with heat flow from granites of the crystal basement. There are some heat flow anomalies, which are conditioned by intensive heat transmitting through deep faults. These fractures are conditioned location of the geothermal energy sources. According to the geothermometers, the aquifer estimated temperatures vary 220 to 270^{o}C. Based on the geothermal modeling, one can suppose that thermal waters rise from 8-12 km deep, where temperature attains to 220^{o}C. The temperature at a depth of 100m ranges 6.7 to 18.8°C, in average 16.4^{o}C and at a depth of 500m from 21 to 27.7°C. The temperature ranges up to 105.8°C at a depth of 6000m (Frashëri A. et al. 2004).

6. Platform for integrated and cascade use of the mineral and thermal waters

The geothermal situation in Albania offers three directions for the exploitation of geothermal energy (Frashëri A: & Kodheli N. 2010): Firstly, the integrated uses of the heat flow of shallow geological section for space heating/cooling; Secondly, thermal sources of low enthalpy in a wide territory of Albania represent the basis for a successful *complex and cascade use* of their energy, achieving an economical effectiveness: a) modern SPA-Wellness for recreation and treatment of different diseases, with thermal pools, for development of eco-tourism; b) the hot water for space heating, for sanitary water, greenhouses and aquaculture installations; c) extract very useful chemical microelements as iodine, bromine, chlorine etc., other natural salts, and H_2S and CO_2 gases, as well as for bottling of mineral waters. Thirdly, the use of deep doublet abandoned oil and gas wells and single wells for geothermal energy, in the form of a "Vertical Earth Heat Probe". Near of these wells can be build greenhouses.

7. Conclusions

In Albania four provinces of thermomineral waters are distinguished. Based on the chemical data, the thermomineral waters could be classified into three most relevant types. The SO_4-Ca type, reach in H_2S gas occurs in the areas of gypsum deposits, the mixed Cl-SO_4-Na-Ca gas types reach in H_2S occurs in limestone sediments underlined by gypsum deposits of Kruja and Ionian provinces. The Na-Cl type reach in CH_4 gas underground waters are related to molasses sediments of Adriatic basin province. The highest measured temperature of thermomineral water of Albania is 83° C, but the temperature calculated by the geothermometers results more than 200° C.

The resources of geothermal energy of low enthalpy of Albania could be integrated and cascade direct use as an alternative energy. Resources of the geothermal energy in Albania are: high temperature springs (temperature up to 65.5° C), as well as shallow groundwater and bedrocks, with have an average temperature about 16.0^o C, and depth Earth Heat Flow. Installation of the space-heating system, using shallow borehole-heat exchanger-Geothermal Heat Pumps systems present the most important direction of the use of geothermal energy.

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SISTEMET MODERNE TË NGROHJES DHE FRESKIMIT TË GODINAVE ME ENERGJINË GJEOTERMALE.

Prof. Dr. Alfred Frashëri

1. Nxehtësia e tokës është energji alternative, miqësore me mjedisin, që duhet shfrytëzuar edhe në Shqipëri

Shfrytëzimi i energjive të rinovueshme është prirja e sotme në vëndet e përparuara të botës, për disa arësye: së pari per te plotësuar kërkesat energjetike qe nuk plotësohen nga resurset energjetike të lëndëve djegëse dhe së dyti, janë energji miqësore për mjedisin. Gjatë shfrytëzimit të energjive të rinovueshme nuk çlirohen gazra që krijojnë efektin serë dhe nuk kanë impakte negativetë mëdha mbi mjedisin, madje shpesh herë ndikojnë për përmirësimin e ekosistemeve.

Prandaj është e kuptueshme që zhvillimet energjetike bashkohore karakterizohen sot, në shtetet ë përparuara të Komunitetit Evropian, në SHBA, në Japoni etj., nga shfrytëzimi gjithënjë e më shumë e energjive të rinovueshme si e ujit, e Diellit, e erës, gjeotermale dhe e biomasës. Toka është një planet i nxehtë. Llava e vullkaneve dhe ujërat e nxehta të shumë burimeve janë dëshmimtarët më të mirë të nxehtësisë së Tokës në thellësi. Shfrytëzimi i drejtpërdrejtë i energjisë gjeotermale zë një vend të rëndësishëm në bilancin energjetik pas energjisë hidrike. Energjia gjeotermale është energji alternative, miqësore me mjedisin, me efekte

shrytëzimi integral dhe kaskadë. Ajo shfrytëzohet edhe drejtpërsë drejti në shumë fusha të veprimtarisë jetësore dhe ekonomike. Në nivel botëror, në vitin 2005 kapaciteti i instaluar dhe energjia gjeotermale e shfrytëzuar drejtpërdrejtë, ka patur këtë strukturë (Lund J., World Geothermal Congress 2005):

Përdorimi	Kapaciteti i instaluar në MWt	Energjia e përdorur në TJ/vit
Pompa gjeotermale nxehtësie për ngrohje dhe freskim të godinave	15,723	86,673
Banja termale	4,911	75,289
Ngrohje godinave	4,158	52,868
Sera	1,348	19,607
Akuakulture	616	1-,969
Përdorime industriale	489	11,068
Gatim	338	1,885
Tharje produktesh bujqësore	157	2,013
Të tjera	86	1,045
TOTAL	**27,825**	261,418

Potenciali real i energjisë gjeotermale mund dhe duhet të shfrytëzohet për qëllime ekonomike edhe në Shqipëri.

Albanidet, që përfaqësojnë strukturat gjeologjike në territorin shqiptar, kanë fluks gjeotermal të aftë për tu vënë në shfrytëzim. Në Shqipëri ka edhe shumë burime dhe puse të ujrave termale, të energjisë gjeotermike të entalpisë së ulët. Në Shqipëri ka edhe shumë burime dhe puse, të cilët japin ujëra me temperaturë deri 65.5 ^{o}C dhe me debite deri 15 l/sek. Këto janë burim i energjisë së rinovueshme, që duhet te fillojë të shfrytëzohet në Shqipëri.

Për të filluar shfrytëzimin e kësaj energjie në Shqipëri, duhet:

Së pari të sensibilizohet opinioni publik, administrata publike dhe investitorët shqiptarë per efektivitetin e saj.

Së dyti, aktualisht në Shqipëri ekzistojnë studime gjeotermike, hidrogjeologjike, hidrokimike dhe biologjike të ujërave termale, si edhe studime mjekësore. Fakulteti i Gjeologjisë dhe i Minierave, Universiteti

Politeknik i Tiranës, botoi në muajin tetor 2004 "ATLASI I BURIMEVE TË ENERGJISË GJEOTERMALE NË SHQIPËRI", në kuadrin e Programit Kombëtar për Kërkim e Zhvillim "Pasurite Natyrore", 2003-2005.

Në Atlas argumentohet se strukturat gjeologjike të Shqipërisë janë bartëse të rezervave të mëdha të energjisë gjeotermale të entalpisë së ulët (Fig. 1, 2). Mbështetur në kapacitetet e energjisë gjeotermale në Shqipëri, si edhe në përvojën boterore të shfrytëzimit të kësaj energjie me teknologji moderne dhe me efektivitet ekonomik të lartë, tërheqim vëmendjen e komunitetit të biznesit shqiptar se ka mundësi të krijoje bisnese të reja fitim prurëse në disa drejtime:

1. **Shfrytëzimi integral dhe kaskadë** i nxehtësisë së ujërave gjeotermale. Ky shfrytëzim i ujërave termale të burimeve ose të puseve lehtësohet nga fakti se ato përgjithësisht ndodhen në zona të zhvilluara nga ana urbane në Shqipëri. Deri tani vetëm disa ujëra të burimeve termale, si ato të Lixhave në Elbasan, Në Bilaj të Fushë Krujës, të Peshkopisë etj shfrytëzohen vetëm për kurimin e sëmundjeve të ndryshme. Por ky shfrytëzim i kësaj energjie në mënyrë primitive, si koncept dhe si mundësi zhvillimi. Këto ujëra mund të shfrytëzohen me efektivitet të lartë ekonimik për:
2.

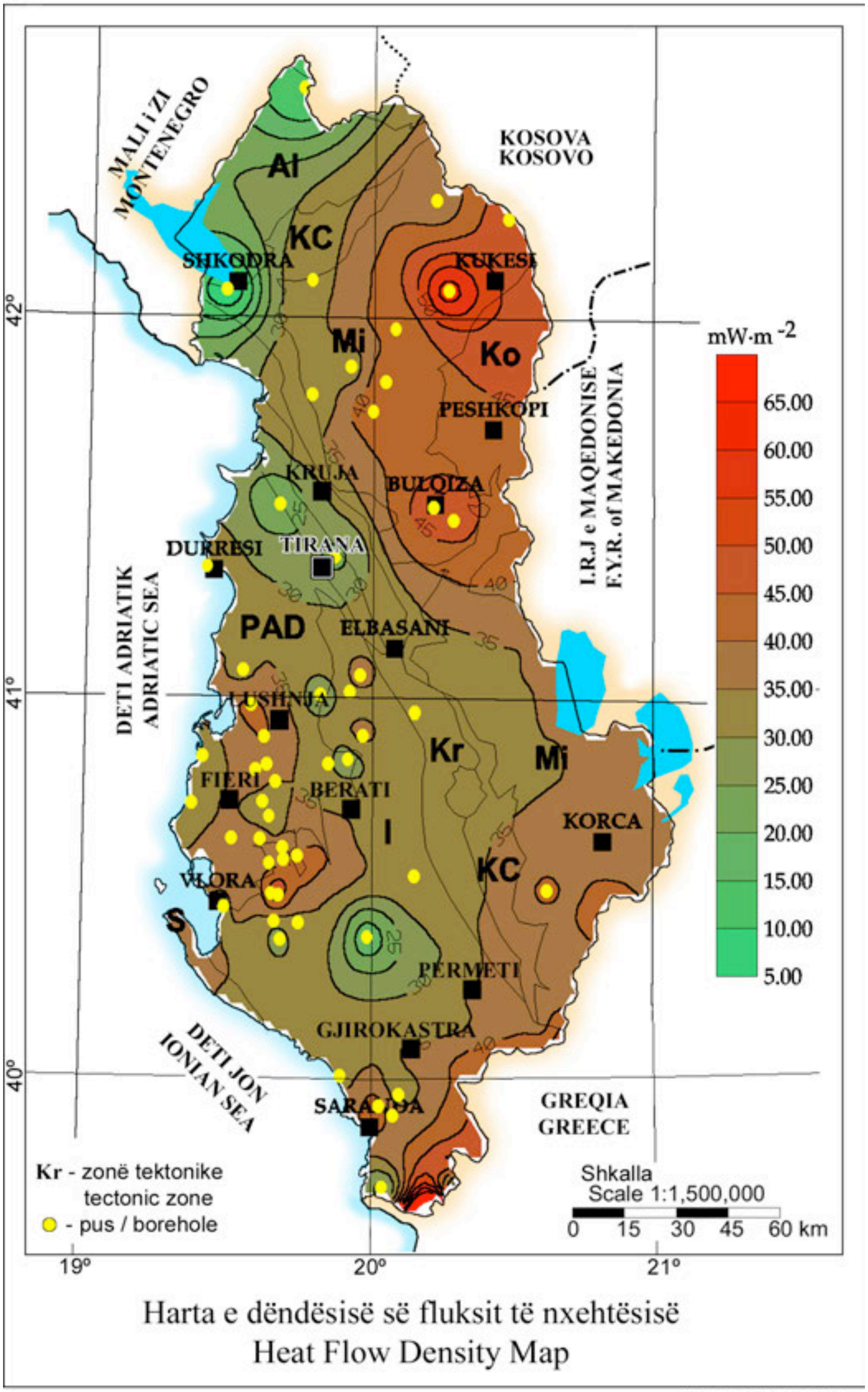
a) Ekoturizmin gjeotermal. Mjafton të përmëndim se në Itali, qëndrat komplekse gjeotermale i vizitojnë rreth 2.5 milion turistë/vit. Mund të ndërtohen hotele me pishina me ujë të ngrohtë, me sauna, me salla e fusha sportive, me lokale argëtimi, etj.

b) Klinika mjekësore moderne, për të tërhequr edhe paciente të huaj, që duan të shfrytëzojnë vetitë e rralla kuruese të shumë ujërave termave të vendit tonë.

c) Ngrohjen e serave dhe zhvillimin e akuaulturës (rritje rasati të peshve dekorative dhe të rrallë, si edhe të algave me të cilat prodhohen pomadat më të shtrenjta për shumë sëmundje dhe kozmetike.

d) Nxjerrje e kripërave dhe e mikroelementeve të dobishëm.

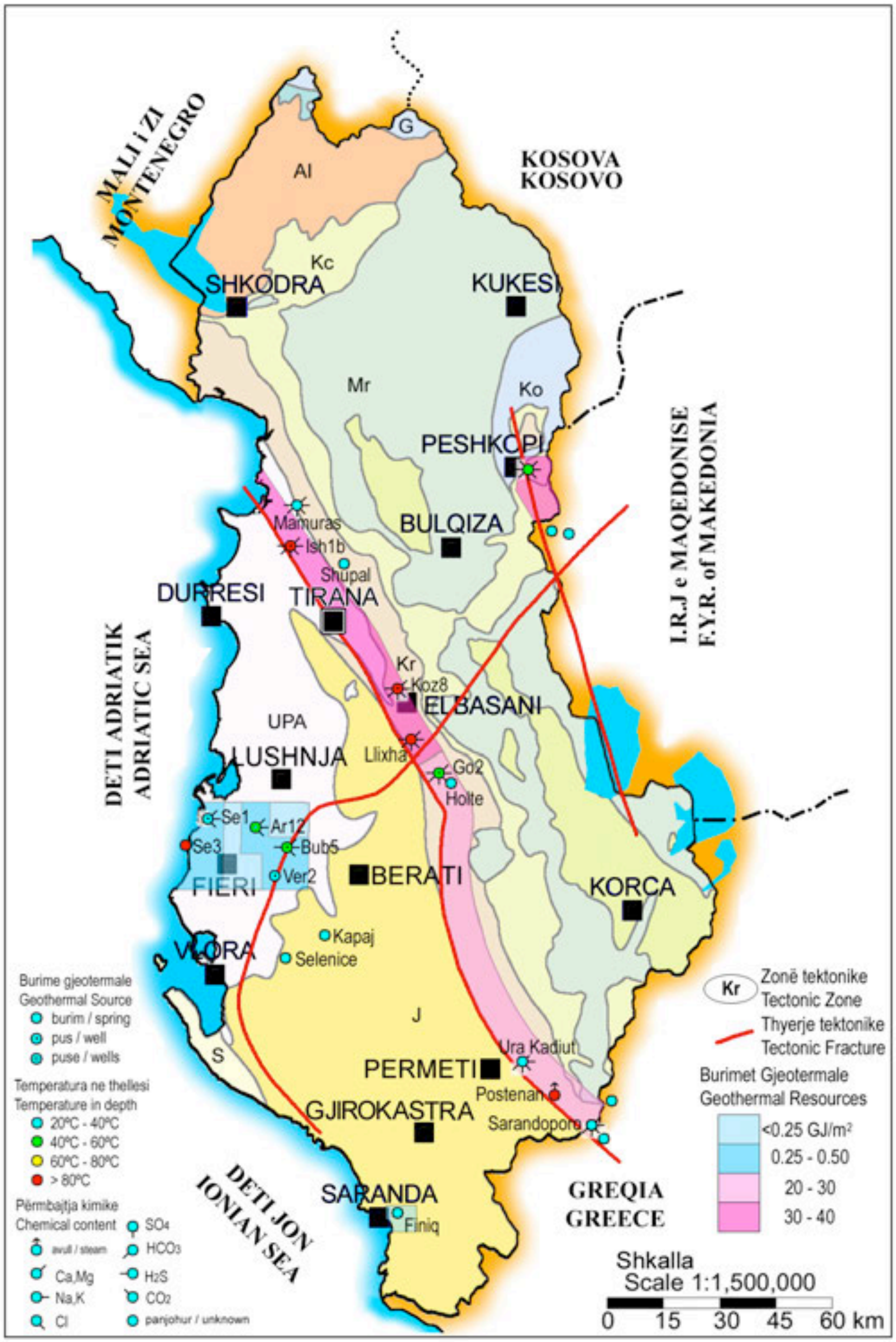
e)Industrializim i ujërave minerale të veçantë.



Harta e dëndësisë së fluksit të nxehtësisë
Heat Flow Density Map

Fleta / Plate 16

Fig. 1



Harta tematike gjeotermale
Geothermal Thematic Map

Fleta / Plate 17

Fig. 2

Foto 1. Llixhat e Elbasanit

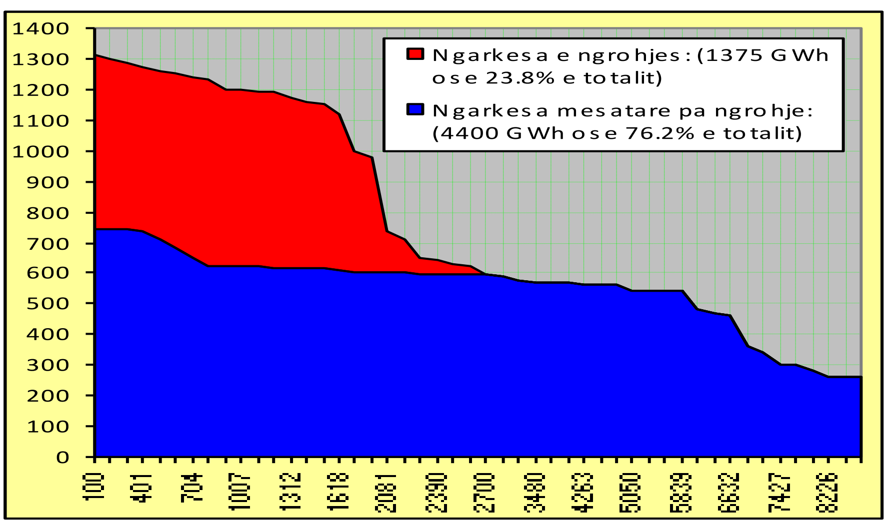
Foto 2. Pusi gjeotermal Kozani-8

Foto 3. Burimet gjetemale të Bënjës, Përmet

Foto 4. Përroi i Banjës, Peshkopi

2. Ngrohja dhe freskimi i banesave me sistemin moderne *pus-këmbyes vertikal nxehtësie-pompë gjeotermale nxehtësie* (BHEGHP). Rëndom, kur bëhet fjalë për energjinë gjeotermale, njerëzit nënkuptojnë vetëm ujërat e ngrohta të burimeve. Kjo është një pjesë e të vërtetës. Por këto ujëra janë zakonisht të rrallë dhe të pakët. Ajo që ka kudo dhe në sasi të mëdha është nxehtësia e shtresave të tokës që nga pjesët pranësipërfaqësore e deri në thellësi të mëdha. Kësisoj, burimi kryesor i energjisë gjeotermale është nxehtësia e këtyre shtresave. Ky duhet të jetë drejtimi kryesor i përdorimit të energjisë gjeotermale është shfrytëzimi i nxehtësisë së shtresave të Tokës Këto sisteme, për të njëjtën kapacitet ngrohës ose freskues, duke shfrytëzuar energjinë gjeotermale, konsumojnë mesatarisht mbi 3 herë më pak energji elektrike, në krahasim me kondicionerët me pompa nxehtesie ajër-ajër, që përdoren sot në vendin tonë, ose ngrohja me këto sisteme është mbi katër herë më të lirë sesa ngrohja me kaldajë me naftë.

Kriza energjetike e vendit, kërkesa gjithnjë e në rritje të energjisë për ngrohjen dhe freskimin e banesave, që në vitin 1999 zinte 23.8% të totalit të energjisë elektrike të prodhuar në vend dhe sot është akoma më tepër, si edhe shkuarja qoftë edhe gradualisht drejt zbatimit të normave europiane për ngrohjen e banesave, për të lënë mprapa ngrohjen vetëm të një dhome nga shqipëtarët në shekujt e varfërisë së tyre, na nxitën të mendojmë për të kontribuar në zgjidhjen e këtij problemi. Çështja bëhet akoma më problemore me përdorimin e naftës e gazit për ngrohje, të cilat veç të tjerash emetojnë në atmosferë sasi të mëdha gazi CO_2.



Kurba e vazhdueshmerisë vjetore të ngarkesës elektrike pa ngrohje me ngrohjen për vitin 1999 (Energjia elektrike totale e furnizuar 5775 GWh), (Agencia Kombëtare e Energjisë).

Ngrohja e godinave publike dhe shtëpive të banimit, si edhe serave me anën e nxehtësisë së shtresave pranësipërfaqësore të tokës është një nga drejtimet aktuale që po përjeton një bum të madh në vendet e Evropës dhe në SH.B.A., Kanada, Japoni etj.

Për këtë qëllim, përdoret Sistemi Këmbyes Nxehtësie-Pus (KNP)- Pompë Gjeotermale Nxehtësie (PGjN), i cili shfytëzon burimet vendore të energjisë, siç është nxehtësia e shtresave pranësipërfaqësore, për ngrohjen e banesave.

Burime nxehtësije mund të jenë:

a) Shtresat pranësipërfaqësore deri në thellësinë 100-150 m.

b) Uji nëntokësor, i ngrohur nga nxehtësia e shtresave.

c) Uji i liqeneve dhe i deteve

Nxehtësia nga shtresat e tokës merret me anën e këmbyesve të nxehtësisë, të disa tipave. Një këmbyes vertikal i nxehtësisë (Fig. 3), koaksial ose në formë U-je, instalohet në shpime 30-150 m të thellë. Fluidi që qarkullon nëpër këtë këmbyes nxjerr nxehtësinë nga shtresat e Tokës. Këto sisteme këmbyesish nxehtësie emërtohen ***me qark të mbyllur.*** Në Shqipëri, ku këto shtresa kanë temperaturë 5-20°C në këmbyes mund të qarkullojë ujë, sepse nuk ka rrezik ngrirje të tij. Këmbyes të shumfishtë, të instaluar në bateri pushesh përdoren për të ngrohur godina të mëdha ose blok godinash publike (Fig. 4)..

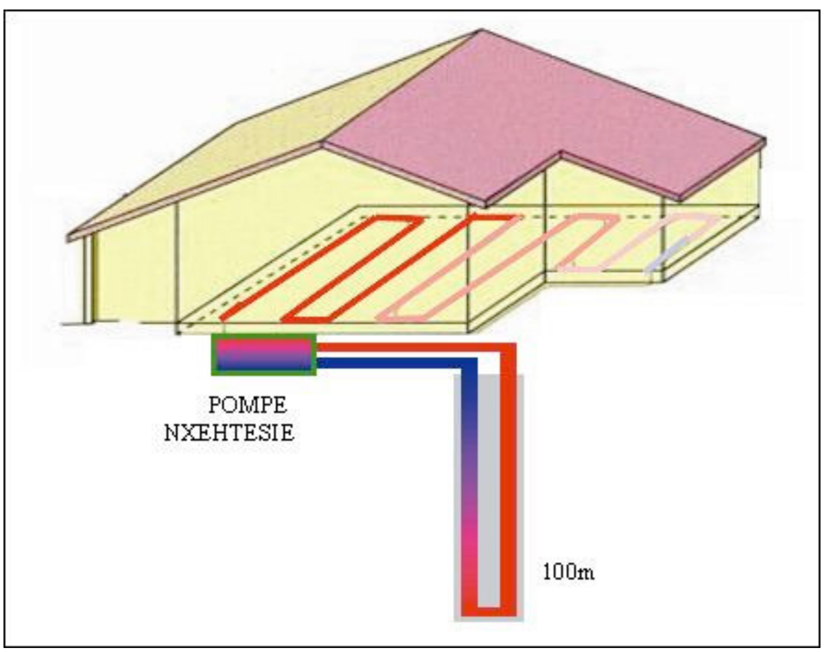


Fig. 3. Këmbyes vertikal nxehtësie në pus 100 m të thellë.

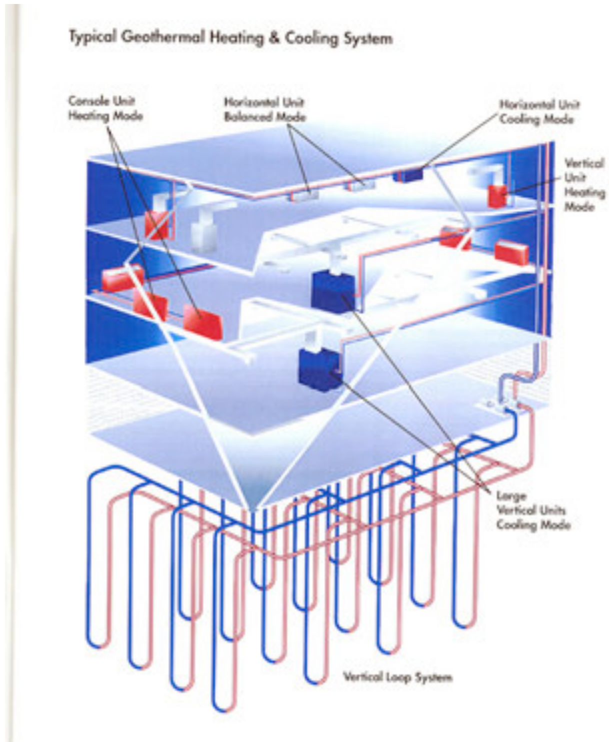


Fig. 4. Bateri pusesh për këmbyesit vertikal të nxehtësisë.

Në zona ku përreth godinës ka tokë, mund të përdoret këmbyes nxehtësie i vendosur horizontalisht, në transhe 1-2-1.8m të thellë (Fig. 5), i cili mund të ketë forma nga më të ndryshmet. Natyrisht, efektiviteti i këtyre këmbyesve të nxehtësisë, sepse në to ka ndikim të madh ndryshimi i klimës.

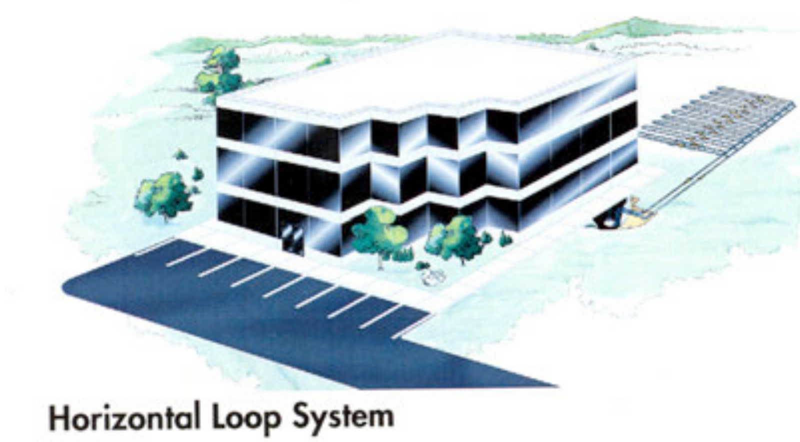
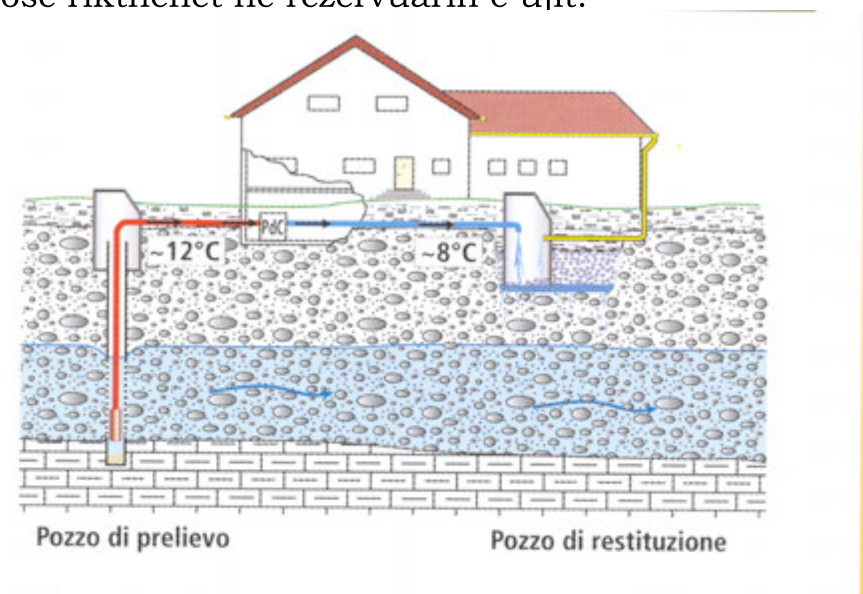


Fig. 5 Këmbyes horizontal nxehtësie i thjeshte

Kur shfrytëzohet nxehtësia e ujërave nëntokësore ose e liqeneve e deteve, sistemet emërtohen ***me qark të hapur*** (Fig. 6). Nga nëntoka ose rezervuari merret uji, i cili dërgohet drejt përse drejti në pompën e nxehtësisë ujë-ujë. Kur merret uji i detit, për të evituar korrozionin, uji i detit futet në një këmbyes nxehtësie. Pasi kalon në pompën e nxehtësisë ose në këmbyesin e nxehtësisë uji i detit, ai injektohet përsëri në shtresat nëntokësore, ose rikthehet në rezervuarin e ujit.



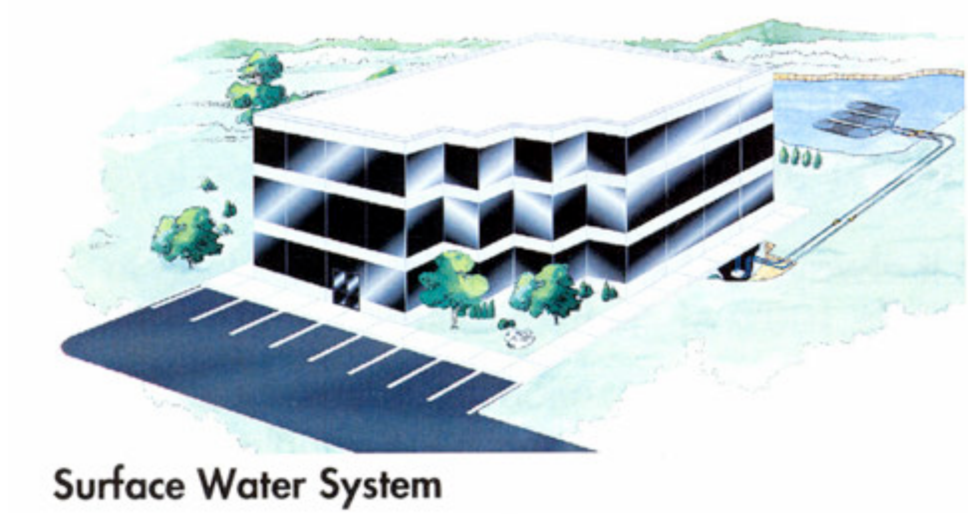


Fig. 6. Sistemi me qark të hapur: a) Pus- Pompë gjeotermale nxehtësie; b) Liqen-Pompë gjeotermale nxehtësie për ngrohjen e banesave dhe te serave.c) Konstruksion i pusit (b).

Aktualisht këto janë sistemet më moderne, me efektivitetin ekonomik më të lartë dhe konsumin më të vogël të energjisë elektrike, me teknologji më të përparuar miqësore me mjedisin dhe po bëhen gjithënjë e më shumë më popullore.

Në 26 shtete në Europë dhe në SHBA, sipas te dhenave jo te plota per vitin 2005 janë montuar 900 mijë instalime BHE-HP, më fuqi 12 kW sejcila, për ngrohjen dhe freskimin e shtëpive-vila, por ka edhe mijëra instalime më fuqi deri 500-1500 kW për ngrohjen e institucioneve dhe të blloqeve të banesave komunale (Ryback L. et al. World Geothermal Congress 2005). Kapaciteti i instaluar është 15 723 MWt dhe energjia e shfrytëzuar 86 673 TJ/vit (24 200 GWh). Në Gjermani aktualisht ka mbi 40 mijë instalime. Në vitin 2005 janë instaluar 6799 pompa gjeotermale nxehtësie dhe vetëm 1526 kondicionerë me pompa ajër-ajër. Shëmbull tipik është edhe Zvicra, ku ka 25 000 instalime, me fuqi të pompës nga 19-40 kW, të cilët shfrytëzojnë nxehtësinë e shtresave pranësipërfaqësore të tokës me temperaturë 10^{o}C. Në Austri ka 23 000 instalime, në Suedi 200 000, në Danimarkë 43 000, në Francë 40 000, në USA 600 000 instalime etj (Curtis R. et al. 2005).

Vendi	Fuqia e instaluar MWt	Energjia e dhene GWh/vit	Numbri i instalimeve
Sh.B.A.	6,300	6,300	600,000
Suedi	2,000	8,000	200,000
Gjermani	560	840	40,000
Kanada	435	300	36,000
Zvicër	440	660	25,000
Austri	275	370	23,000

2. Tabloja e energjisë gjeotermale të shtreseva pranë sipërfaqësore në Shqipëri.

Ashtu si kudo, edhe në Shqipëri shtresat pranësipërfaqesore të Tokës kanë nxehtësi. Nga analiza e gjendjes së regjimit gjeotermal të kësaj prerjeje gjeologjike, rezulton se kjo prerje gjeologjike ka energji gjeotermale e niveleve të tilla që lejon të shfrytëzohet nxehtësia e tyre për të ngrohur godinat (Frashëri A. 2004, Frashëri A. etj. 2004, 2003). Kjo energji mund të shfrytëzohet me sukses për ngrohjen e godinave publike (zyra, spitale, bibioteka, shkolla, teatro e kinema, godina aeroporti etj) si edhe

blloqe banesash e vila për banim, duke shfrytëzuar sistemet moderne të ngrohjes Këmbyes Nxehtësie-Pus-Pompë Gjeotermale Nxehtësie.

Sasia e nxehtësisë, temperatura në sipërfaqen e Tokës dhe gradienti gjeotermal i prerjes gjeologjike praën sipërfaqësore kondicionohen nga kushtet e vendndodhjes gjeografike, kushtet gjeomorfologjike (pjerësia e sipërfaqes së Tokës dhe pozicioni i saj në raport me Diellin), litologjia e truallit dhe e shkëmbinjve rrënjësorë, nxehtësia specifike dhe lagështia, stina dhe moti. Sipas vrojtimeve gjeomorfologjike shumëvjeccare rezulton se mesatarisht 140.000 kalori/cm^2 nxehtësi merr trualli nga rrezatimi diellor gjatë verës në trevat fushore në Shqipëri. Sasia e nxehtësisë arrin në 120.000 kalori/cm^2 në rajonet veri-lindore malore (Gjoka L., 1990).

Shpërndarja e fushës termale në territorin shqiptar, në pajtim me vlerat e gradientit gjeotermal, në në pjesën e sipërme pranësipërfaqësore të prerjes gjeolgjike tregon se temperatura në thellësinë 100m ka vlera si mëposhtë vijon (Fig. 7) (Frashëri A. etj. 2004):

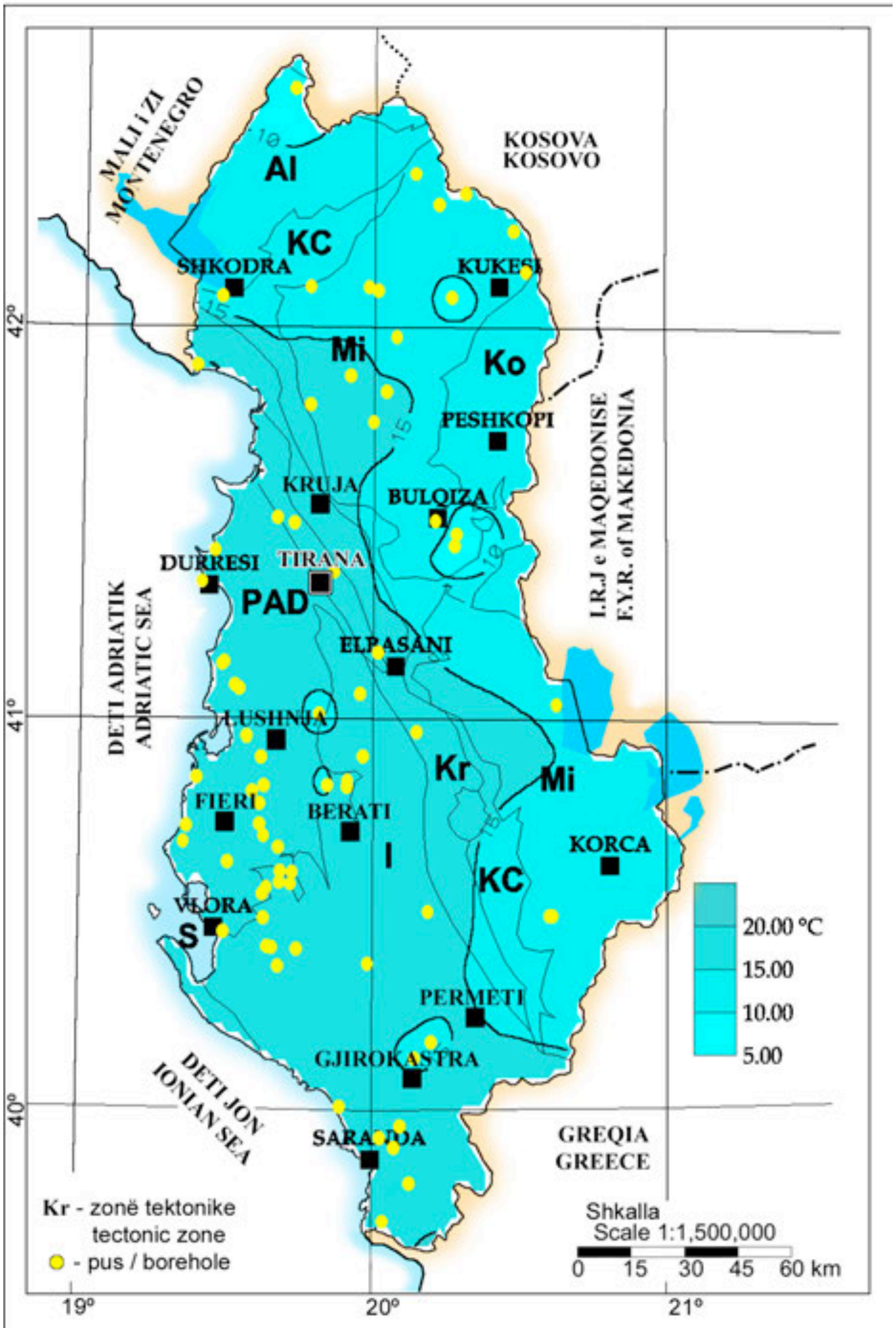
Temperatura në zonën bregdetare:
Minimale 16.6^{o}C
Maksimale 18,8^{o}C
Mesatare 17.8 ^{o}C

Temperatura në zonën perëndimore fushore-kodrinore:
Minimale 17.15^{o}C
Maksimale 18,41^{o}C
Mesatare 18.0 ^{o}C

Temperatura në zonat kodrinore-malore:
Minimale 6.7^{o}C
Maksimale 18,6^{o}C
Mesatare 14.7 ^{o}C

Në fushën e Tiranës (Rinas), temperatura është 15.5^{o}C nga thellësia 20 deri 35m, në depozitimet kuaternare (Fig. 8) (Frashëri A. etj. 2004). Sicc duket nga termograma e pusit në Rinas, nga sipërfaqja e Tokës e deri në thellësinë 20 m, më këtë zonë, temperatura e depozitimeve ndryshon në varësi të stinë dhe përcaktohet nga nxehtësia që Toka merr nga Dielli. Në dimër, temperaturat janë më të ulta, edhe në këtë pjesë të prerjes gjeologjike. Në thellësi më të mëdah, temperatura e depozitrimeve dhe e shkëmbinjve nuk varet nga stinët dhe përcakjtohet nga gradienti gjeotermal normasl i zonës; për rastin e rinasit 15.5^{o}C. Konstatohen ndryshime anësore të temperaturës deri në 0.5^{o}C edhe në distanca deri 500m, në të njëjtën kohë. Këto ndryshime anësore janë kondicionuar nga

litologjia e depozitimeve kuaternare. Është vrojtuar se në rajonet malore të vendit, thellësia e temperaturës që përcaktohet nga rrezatimi diellor arrin deri në 50.



Harta e temperaturës në thellësinë 100m
Temperature Map at the depth 100m

Fleta / Plate 7

Fig. 7

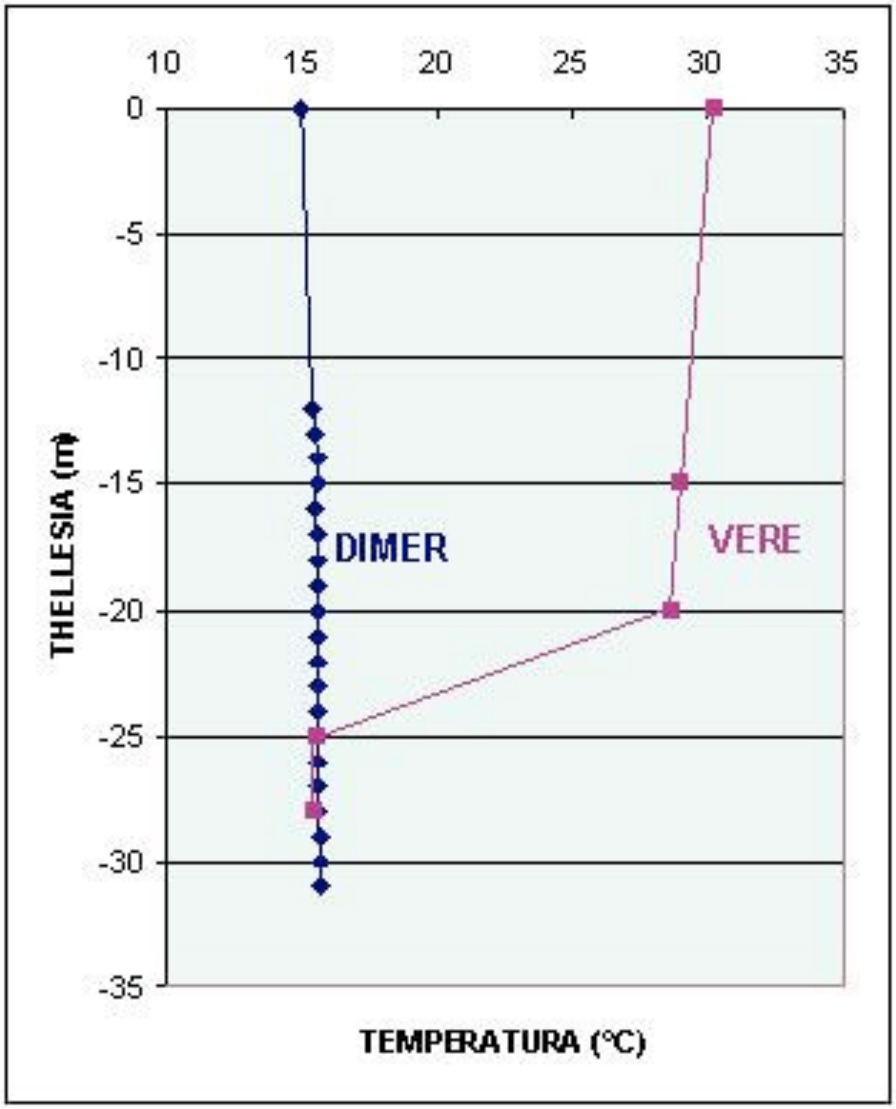


Fig. 8 Termograma e pusit ne fushen e Tiranes (Rinas)

Nxehtësia e shtresave pranë sipërfaqësore të Tokës kanë ngrohur edhe ujërat e rezervuarëve nëntokësorë. Në trevat fushore në perëndim të Shqipërisë, ujërat nëntokësore kanë këto temperatura:

Temperatura e ujit e shtresave zhavorore të kuaternarit është 14-15 °C,
Temperatura e ujit e shtresave ranore të kuaternarit është 15-16 °C,

Për rrjedhoje ujinëntokësor mund të shërbejë si burim nxehtësie për pompat gjeotermale.

3. Vlerësime ekonomike për skemën ngrohëse Pus-Këmbyes vertikal nxehtësie-Pompë gjeotermale nxehtësie

Nga të dhënat e literaturës rezulton se kosto e investimit për sistemet e ngrohjes gjeotermale luhaten 34-216 Euro/m^2 të sipërfaqes së godinës. Kosto më e ulët është në rastet kur si burim nxehtësie shërben uji nëntokësor, për marrjen e të cilit kërkohet të shpohet pus i cekët, në te cilin mund të bëhet edhe ri-injektimi i ujit përsëri në shtresë pasi kalon nëpër pompën gjeotermale. Kosto maksimale del kur burim nxehtësie janë shtresat pranësipërfaqësore dhe pVr tV nxjerrë nxehtësinë kërkohet të shp;ohen puse deri 100m të thellë për të vendosur këmbyesin vertikal të nmxehtësisë. E krahasuar kjo kosto me atë të sistemeve me kaldajë, rezulton se ajo është rreth 135.7% më e madhe.

Sistemet këmbyes nxehtësie-Pus-Pompë Gjeotermale Nxehtësie (KN-P-PGjN) kanë marrë këtë zhvillim megjithesë kanë kosto ndërtimi 30-40 % më të lartë se kosto e sistemeve ngrohëse konvencionale më boiler nafte. Ka disa arsye për këtë:

1) **Konsiderata ekonomike**. Aktualisht, kosto e instalimit te KN-P-PGjN është më e madhe sesa e instalimeve konvencionale me karburant. Megjithë këtë kosto vjetore e “karburantit” te sistemit KN-P-PGjN (energjia elektrike për pompën termike dhe pompën e qarkullimit) janë në mënyrë të konsiderueshme shumë më të ulta sesa karburanti i një ngrohësi konvencional me naftë ose gas. Për koeficient performance KP = 3.5, kursehet deri 71% e energjisë elektrike. Kështu, koha e kthimit të shpenzimeve të KNP është më e shkurtër se koha e punës së vetë sistemit ngrohës.

2) **Konsiderata mjedisore**. KNP-pompë termike është një sistem mjedisor i pastër që nuk emeton gaze CO_2 (“efekti serë”), kështu që evitohet për pronarin e shtëpisë pagesa e taksës për emisionin e gazeve CO_2, e cila është në diskutim në vendet e Komunitetit Europian.

3) **Mbështetje qeveritare**. Për instalimin e sistemit KN-P-PGjN, qeveria japoneze jep një investim prej 200 USD për çdo kWe të Pompës gjeotermale të Nxehtësisë, duke patur një limit të sipërm 5 200 USD.

Për një vlerësim të plotë po paraqesim disa preventive, me qëllim që të analizohen dy probleme: kosto e instalimit të sistemit dhe shpenzimet për energjinë elektrike ose për konsumin e naftës të sistemeve të ndryshme ngrohëse, sipas çmimeve aktuale në Shqipëri.

Godina: Hotel

Sipërfaqja e përgjithëshme e 3 kateve:	610 m^2
Ngrohja: me kalorifere (radiatorë)	
Kapaciteti për ngrohje	68.5 KW
Periudha e ngrohjes	1170 orë/vit

Sistemi ngrohës, analizohen tre variante:

a) Pus-pompë gjeotermale nxehtësie
b) Kaldaje me naftë
c) Kondicionerë

Kosto e përgjithëshme paraprake e instalimit:

a) Pus-pompë gjeotermale nxehtësie	43.000 Euro
b) Pus-kemb. Vert. nxehtesie-pompe gjeo. nxeht.	68.461 Euro
c) Kaldaje me naftë	27.000 Euro
d) Kondicionerë, tip “General”	15.600 Euro

Kosto paraprake e instalimit për metër katror të sipërfaqes:

e) Pus-pompë gjeotermale nxehtësie	71,66 Euro/m^2
f) Pus-kemb. Vert. nxehtesie-pompe gjeo. nxeht.	112,63 Euro/m^2
g) Kaldaje me naftë	44,26 Euro/m^2
h) Kondicionerë ajër-ajër, tip “General”	26,00 Euro/m^2

Kosto paraprake vjetore operative e konsumit të energjisë elektrike ose lëndës djegëse gjatë 1170 orëve, për të vënë në punë sistemin ngrohës:

a) Pus-pompë gjeotermale nxehtësie	33.304 kW	3.384 Euro
i) Pus-kem. V. nxeh.-pom. gjeo. nxe.	33.304 kW	3.384 Euro
b) Kaldajë me naftë	2.282 Lit. naft.	11.982 Euro
c) Kondicionerë	93.636 kW	9.515 Euro
d) Radiatorë elektrikë	137.700 kW	13.993 Euro

Kosto paraprake totale vjetore për energjinë ngrohëse:

- **Euro/KW**	Viti parë	Viti dytë
a) Pus-pompë gjeotermale nxehtësie	677,14	49,40
b) Pus-kem. V. nxeht.-pompe gjeo. nxehtësie	1.048,83	174,93
c) Kaldajë me naftë	569,08	138,91
d) Kondicionerë	366,79	204,28

- **Euro/m²**

a)	Pus-pompë gjeotermale nxehtësie	76,04	5,55
b)	Pus-kem. V. nxeht.-pompe gj. Nxehtësie	. 117.78	5.55
c)	Kaldajë me naftë	63,90	19,64
d)	Kondicionerë	41,19	15,60

Në figurat 9, 10 paraqiten grafikët e kostos për konsumin e energjisë elektrike ose të naftës, si edhe koston e përgjithëshme të instalimit dhe të konsumit të lëndës së parë gjatë dhjetë vjetëve të punës së instalimeve me sisteme të ndryshme ngrohjeje. Duket qartë se p*eriudha e vetshlyerjes së investimeve për sistemin "pus-pompë gjeotermale nxehtësie"* është*:*

* 1 vit. Ajo mbulohet vetëm me shpenzimet që do të bëheshin për naftën e kaldajës
* 5 vjet. Ajo mbulohet vetëm me shpenzimet që do të bëheshin për energjinë elektrike të kondicionereve.

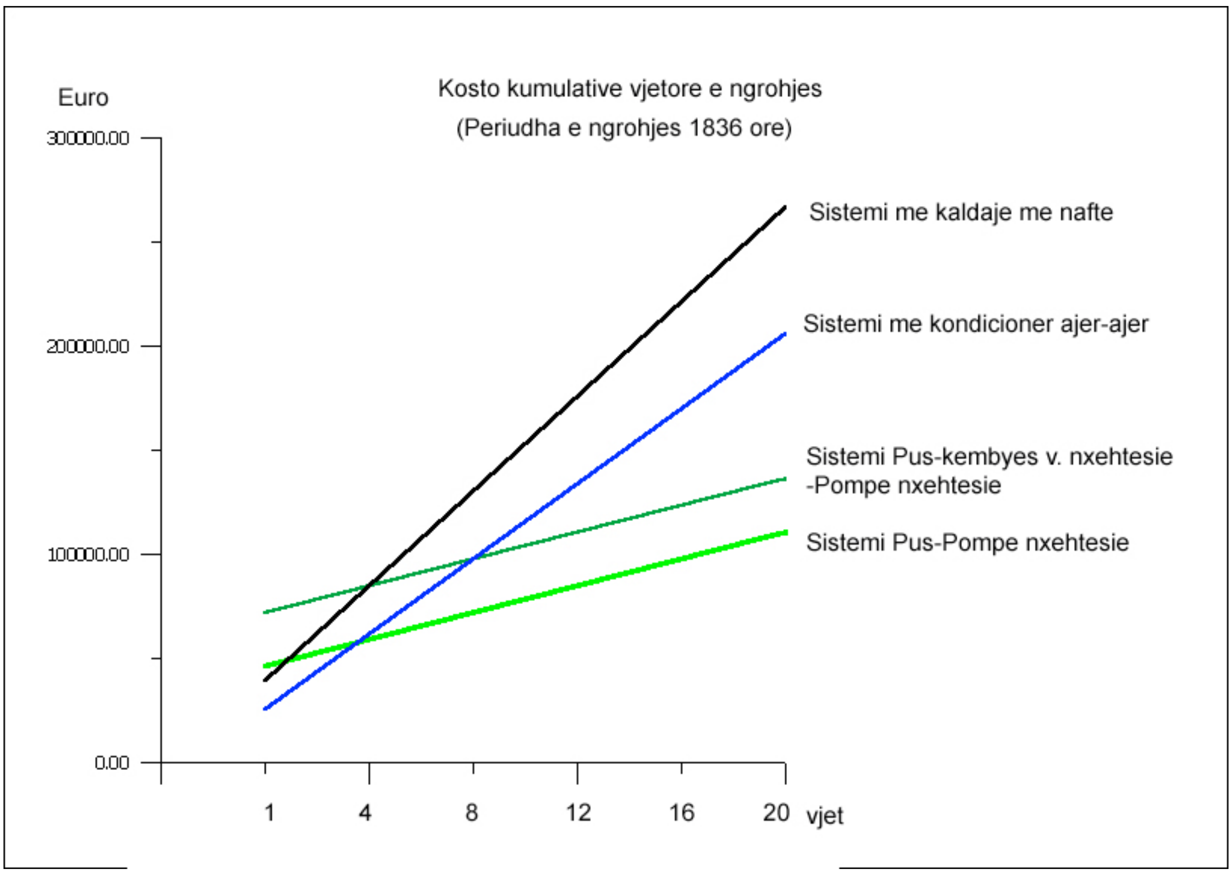


Fig. 9.

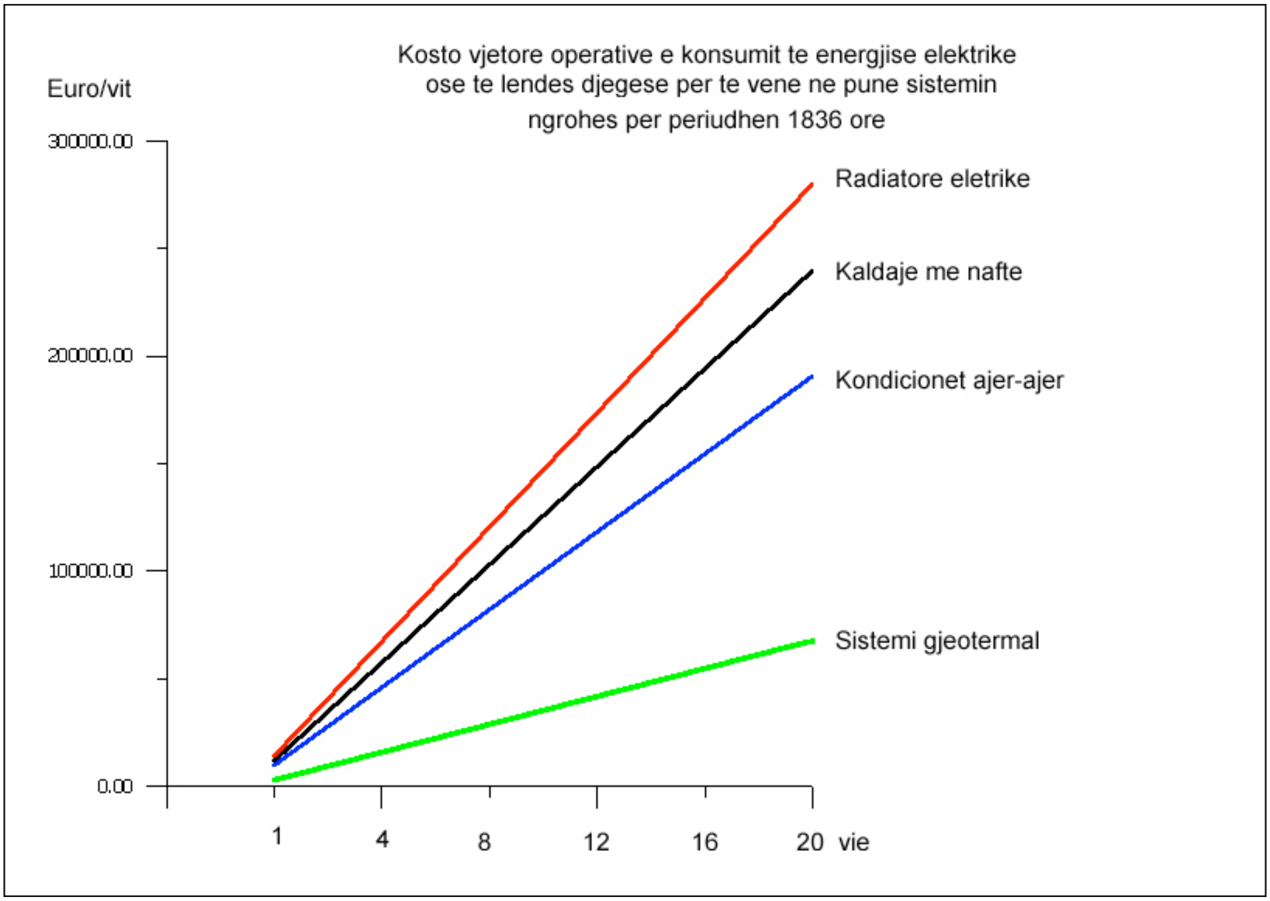
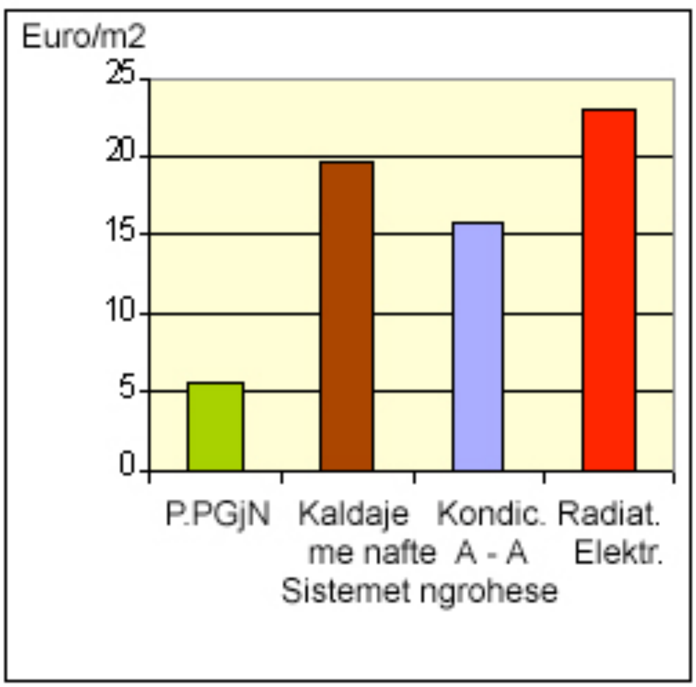


Fig. 10



. 11. Kosto specifike vjetore e ngrohjes me sisteme te ndryshme

Nga vlerësimet e bëra rezulton se kosto njësi e instalimit luhatet 70-184 Euro/m^2, si edhe 630-2120 Euro/kW, në varësi të burimeve të nxehtvsisë. Kosto më e lartë është për rastet e ndërtimit të këmbyesve vertikalë të nxehtësisë në puse. Kosto më e ulët është kur si burim nxehtësie është uji nëntokësor dhe kërkohet pus i cekët për të marrë ujin dhe për ta injektuar pasi kalon nëpër pompën gjeotermale të nxehtësisë. Siç duket nga paqyra e më sipëreme, kosto për instalimin e sistemit gjeotermal është më e lartë sesa kur ndërtohen sisteme ngrohëse me kaldajë ose edhe më kondicionerë ajër-ajër në masën 2-2.8 herë, por kjy shpenzim shlyhet për disa vjet (2-5 vjet) nga kursimi i shpenzimeve për konsumin e naftës opse të energjisë elektrike. Në figurën....... jepet grafiku i kostos në lekë për një njësi (kW) të ngrohjes. Duket qartë se sistemi gjeotermal ka koston më të vogël se të gjitha sistemet e të tjerave.

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DIRECT USE OF GROUND HEAT FOR SPECE HEATING AND COOLING, IN THE LOW ENTHALPY GEOTHERMAL ENERGY AREAS PRESENT A CONTRIBUTION IN COUNTRY ENERGY SYSTEM

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ABSTRACT

The paper presents a detailed analyse of the use of shallow ground heat resources in Albania, for direct use of geothermal energy for space heating/cooling of buildings and greenhouses, and an economical feasibility study results.

The energy requests in Albania, the increased demand in premises, the gradual implementation of European standards of space heating, represent all decisive factors raising the awareness in order to contribute in finding optimal solutions to actual energetic situation. The electric energy consummation for space heating is 1 375 GWh/year, or 23.8 % of the total electric energy production in Albania. The situation becomes more problematic because the use of fossil fuels for heating emits large quantities of CO_2 in the atmosphere.

Both two shallow geothermal sources can be used for Borehole- Heat Exchanger-Geothermal Heat Pump system, which represents a modern system for space heating and cooling in Albania: Ground heat through use of the ground-couplet (closed loop), and underground water system (open loop). The Heat Flow Density has a value of 42-60 $mW \cdot m^{-2}$ in territory of Albania. At the depth 100m the temperatures reaches from 16^oC up to 18.8^o at plain areas in Albania, and 6.70 ^OC up to 18.6 ^OC at hilly-mountains regions. Water temperature of the Quaternary sandstone layers is 15-16^oC.

In Albania actually working first four installations, using water-water thermal pumps. Payback period for the installed cost of open loop system is 2,2 years, and for closed loop system reaches 4,9 years. Installed cost can be covered only by expenses savings for boiler fuel.

Keywords: Geothermal energy, space heating, geothermal heat pumps, direct use, heat flow,.

1. INTRODUCTION

Large numbers of geothermal energy of high and low enthalpy resources, a lot of mineral water sources represent the base for successfully application of modern technologies in Albania, to achieve economic effectively. There are many thermal springs and wells. Their water has temperatures that reach values of up to 65.5°C.

At present, the thermal waters of some springs and wells are used only for health purposes.

The geothermal situation of low enthalpy in Albania offers three directions for the exploitation of geothermal energy (Frasheri et al. 2003):

Firstly, space heating and cooling

Secondly, integrated and cascade use of geothermal waters energy

Thirdly, greenhouses and aquaculture installations.

Direct use of the environmental friendly geothermal energy must be realized by integrated scheme of geothermal energy-heat pumps and solar energy, and cascade use of this energy.

The most important direction is space heating and cooling. The Earth Heat can be use for space heating and cooling by modern systems Borehole Heat Exchanger-Geothermal Heat Pumps.

In the paper is presented a detailed analyse of the shallow ground heat resources in Albania, in particularly in Korça city, and ways for direct use of this energy concretely for heating in Albania.

2. PRESENTATION OF THE PROBLEM

The energy crisis prevailing in the Albania, the increased demand in energy for heating and cooling of premises, the gradual implementation of European standards of premises' heating, are all decisive factors raising the awareness in order to contribute in finding optimal solutions to this critical situation. Actually, the electric energy consummation for heating is 1 375 GWh/year, or 23.8 % of the total electric energy production in Albania (Fig. 1) (National Agency of Energy, Tirana, 2003). The situation becomes more problematic because the use of natural gas for heating emits large quantities of CO_2 in the atmosphere.

In the developed countries such as the Member States of the European Union, in the United States, Japan etc., particular attention is given to the use of renewable energies, among them the geothermal energy (Lund. J.W., et al. 2005, Rybach L., et al, 2005). The Earth's heat is a great source of energy, renewable and friendly to the environment. Direct use of the ground heat by Borehole heat Exchanger-Geothermal Heat Pump represents a modern system for space heating and cooling (Lund J.W., et al. 2005, Rybach L., et al. 2000, 2004).

Alike elsewhere in the world, in Albania the subsurface ground layers contain heat. This energy can be successfully exploited in heating the public premises (offices, hospitals, libraries, theatres, airports etc.) as well as private premises (houses and apartment buildings), using the modern systems of Borehole-Heat Exchanger-Geothermal Heat Pumps.

Two types of shallow heat sources exist: ground heat and underground waters heat. Consequently two kind of technology is possible to applied:

Firstly, ground-source and Borehole heat Exchanger-Geothermal Heat Pump or ground-couplet (closed loop),

Secondly: underground water system – Geothermal Heat Pump (open loop).

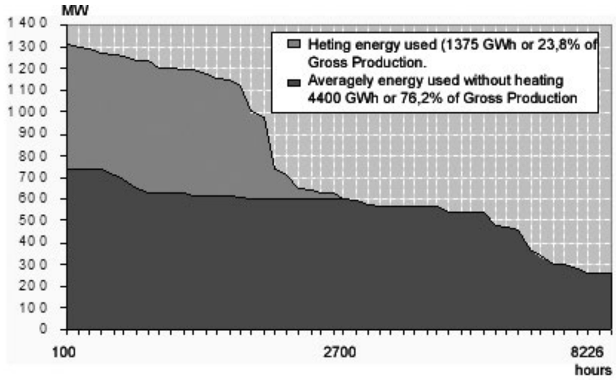

Fig. 1. Yearly electric energy consumption without and with space heating, for 1999 y. (National Agency of Energy).

Ground coupling is used where insufficient well water is available or where quality of the well water is a problem. Multiple Heat Exchangers are installed in large public premises.

Actually, in Albania have set up only first four installations of geothermal heat pumps systems. In order to develop direct use of this renewable geothermal energy and environmental friendly ground heat for space heating and cooling in Albania, we have introduced the idea of building a demonstrative installation for heating and cooling purposes of the important public building in Tirana and in other Albanian cities, ex. University Campus, Hospital, Secondary School, etc. (Frasheri et al. 2003, Frashëri A. 2008, Frashëri A. et. al. 2008). It will be of great professional satisfaction if this proposal will find application. It will contribute in solving the problematic issue of heating and cooling of premises in Albania.

The implementation of this project contributes in raising the awareness of the public administration, of the business and scientific communities, to make use of this economically optimal solution for heating and cooling of premises. The public administration should introduce the necessary tools and incentives for enabling the entering into the market of such modern and environmentally friendly systems. The business community should have in consideration and invest in installation of these Borehole-Heat Exchanger-Geothermal Heat Pumps, making way for new businesses. The universities should teach about these modern systems and insists on their applicability.

3. A WORLDWIDE EXPERIENCE

In 26 European countries and United States there are installed 570 000 installations BHE-HP, with a power of 12 KW each, for heating and cooling of houses, but also there are thousands installations with a power of up to 500-1500 KW for heating of institutions and of apartment buildings (Lund J. W., et al. 2005, Rybach L., et al. 2005). In Germany there are 50 000 installations. Switzerland is a typical example with 21 000 installations, with a pump power from 19-40 KW, which exploits the heat of nearsurface earth layers with

a temperature of 10oC. In Switzerland, in 1980 the production of geothermal energy by these systems was 70 GWh, in 1999 it is increased up to 365 GWh. Japan (Japan Times, Jan. 21, 2003), using the geothermal energy of subsurface ground layers saves up to 40% of the total energy. The expenses necessary to carry out this project will be paid within 10 years. Two thirds of the building costs, valued up to 10 million yen for the government and local authorities support each installation.

Ground-couplet systems have been used in Northern Europe for many years. Actually, these modern systems in use, highly effective and with low consume of electric energy, technologically advanced and environmental friendly, are gaining huge popularity (Rybach L. et al, 2000).

Borehole-Heat Exchanger-Geothermal Heat Pump systems are developed even though has a construction cost 30-40 % higher than the conventional heating by gas. There are several reasons for this:

Economical considerations. Actually, the cost of installing the Borehole-Heat Exchanger-Geothermal Heat Pump is higher than the conventional fuel installations. Nonetheless, the annual cost of "fuel" of the Borehole-Heat Exchanger-Geothermal Heat Pump (Electric energy for the heat pump and circulating pump) are considerably lower than the fuel of the conventional heating by gas. ***For the coefficient of performance 3, is saved up to 66% of the electrical energy.*** Consequently, the payback of the Borehole-Heat Exchanger-Geothermal Heat Pump system is shorter than the durability of using the other heating system.

Environmental considerations. Borehole-Heat Exchanger-Geothermal Heat Pump is an environmental system that does not emits CO2 ("greenhouse effect"), therefore the proprietor avoid paying the tax on emittance of CO2 gas, which is under discussion in the countries of the European Community.

Governmental support. The Japanese government has invested 200 USD for every kW of the Pump of Geothermal Energy, with an upper limit of 5 200 USD.

4. GROUND GEOTHERMAL ENERGY RESOURCES IN ALBANIA

Heat quantity, temperature at Earth surface, and geothermal gradient in shallow geological section, are conditioned by geographical location, geomorphological conditions (Earth surface dip and position in relation by Sun), ground and bedrocks lithology, specific heat and humidity, season and weather. According to the multy annual meteorological surveys result that in average is 140,000 calory.cm^{-2} heat from solar radiation of the ground during the summer at the plane areas of the Albania. Heat quantity reaches 120,000 calory.cm^{-2} at northeaster mountains regions [Gjoka L., 1990].

Thermal field distribution and geothermal gradient values in the ground at shallow geological section are conditioned that at the depth 100m the temperatures reaches from 16oC up to 18.8^{o}C at plane areas in the Ionian tectonic zone and in Peri Adriatic Depression (Fig. 2). The areas with a temperature between 18 °C and 19 °C are located at Kolonjë-Divjakë-Kryevidh, Vlorë and Sarandë-Delvinë zones (Frashëri A., et al. 2004, 2008).

There are some particularities in the distribution of the temperature at the depth 100m:

Temperature in subsurface ground at littoral area:

Minimal temperature is 16.60 ^{O}C

Maximal temperature is 18.80 ^{O}C

Average temperature is 17.80 ^{O}C

Temperature in subsurface ground at western plane-hilly area:

Minimal temperature is 17.15 ^{O}C

Maximal Temperature is 18.41 ^{O}C

Average Temperature is 18.0 ^{O}C

Temperature in subsurface ground at hilly-mountains regions:

Minimal temperature is 6.70 ^{O}C

Maximal temperature is 18.60 ^{O}C

Average temperature is 14.75 ^{O}C

In plane area of Albania, example in the Tirana field (Rinasi), the temperature is 15.5 ^{o}C, up to logging depth 31 m, in the Quaternary deposits (Fig. 3) (Frashëri et al. 2003). According to the well-known data, the layers at the depth from 0-8-10 m have a temperature, which is conditioned by solar radiation energy. During the winter, the temperature is lower than during the summer. Below, the ground temperature is constant during the year, because don't have the influence from solar radiation. Depth limit of the solar radiation influence zone is not unique. Lateral changes up to 0.5 ^{o}C are observed in the 500m distances, for the same time. These lateral changes are conditioned by lithology of the Quaternary loose deposits. The belt of the constant temperature continues up to the depth 50 m in the mountain regions of the Albania.

According to the analyse of the geothermal regime of the shallow geological section is concluded that is possible to use the ground heat for the space heating and cooling, applied modern Borehole Heat exchanger – geothermal Heat Pump. Ground geothermal energy has heated the underground water reservoir (Fig. 3,4). In Tirana underground water basin are following temperatures:

Water temperature of the Quaternary gravel layer is 14-15 ^{o}C. Water temperature of the Quaternary sandstone layers is 15-16^{o}C. Consequently, concluded that water of the Tirana underground basin can be a heat source for the geothermal pumps.

5. ECONOMIC EVALUATION OF THE PROPOSED SCHEME HEATING OF UNIVERSITY "FAN NOLI", KORÇA CITY

Total heated surface, for three-floors:1200 m^{2}

Heating system: Borehole-Heat Pump-Radiators

Heating capacity 134 KW
Heating period 1836 hours

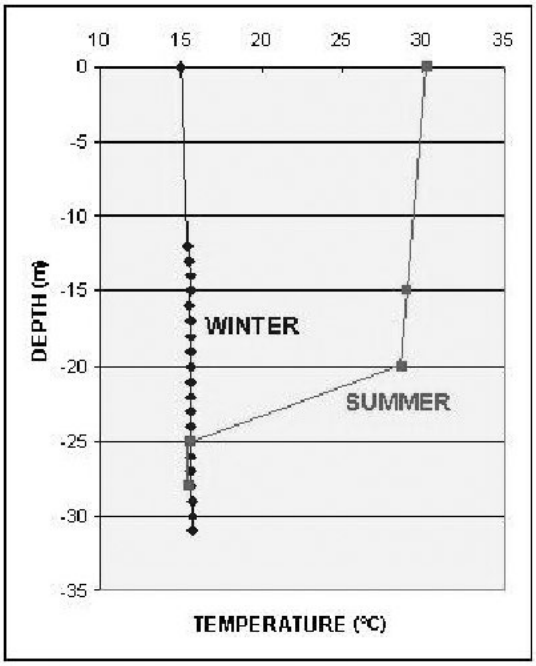

Fig. 3. Thermolog of the Rinasi borehole

Heating system**,** there are analyzed three variants:
a) Borehole-Geothermal Heat Pump
b) Borehole-Heat Exchanger-Geothermal Heat Pump
b) Oil Fired Boiler

Installed cost for:
a) Borehole-Geothermal Heat Pump 58.101 Euro
b) Borehole-Heat Exchanger-Geothermal Heat Pump 121.123 €
c) Oil Fired Boiler 16.579 €

Specific Installed cost for:
a) Borehole-Geothermal Heat Pump 59.3 Euro/m^2
b) Borehole-Heat Exchanger-Geothermal Heat Pump 109.3 Euro/m^2
b) Oil Fired Boiler 15.6 Euro/m^2

Yearly expenses for the oil for boiler and electric Energy for geothermal heat pumps:

- Oil for boiler 39.960 Euro
- Electric energy for Borehole-Heat Exchanger-Geothermal heat pump system 26.970 Euro
- Electric energy for Borehole-Geothermal heat pump system 24.814 Euro

Payback period for the installed cost for:
- Payback period of Borehole-Heat Exchanger Geothermal heat pump system 2,2 years
- Payback period of Borehole-Geothermal heat pump system 4,9 years

Installed cost can be covered only by expenses savings for boiler fuel.

In fig 5 is presented the graphic of the installed costs and yearly expenses for the oil and electric energy for the geothermal heat pumps for space heating for different heating systems.

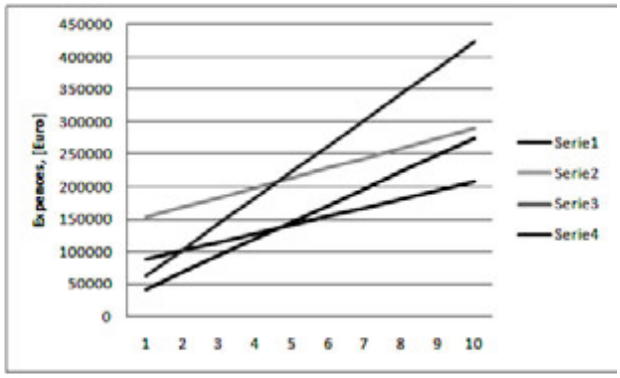

Fig. 5. Installed costs and yearly expenses for fuell and electric energy for the geothermal heat pumps for space heating for different heating systems.
Legend: Serie 1: Borehole-Geothermal Heat Pump system , Serie 2: Borehole-Heat Exchanger Geothermal Heat Pump system ; Serie 3: Boiler system, oil price 1,2 Euro/liter;
Serie 4: Boiler system, oil price 0.8 Euro/liter.

Fig. 6 shows the cumulative yearly expenses for the fuel and electric energy for heating system works.

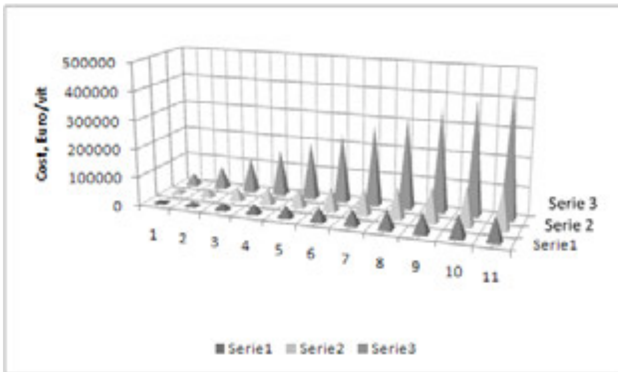

Fig. 6. Cumulative yearly expenses for the oil and electric energy for the geothermal heat pumps for space heating for different heating systems (in Euro).
Legend: Serie 1: Borehole-Geothermal Heat Pump system , Serie 2: Borehole-Heat Exchanger Geothermal Heat Pump system ; Serie 3: Boiler system.

In the fig. 7 is presented the plots of the differences of yearly cumulative expenses for the fuel and electric energy for the geothermal heat pumps for space heating and installation costs for different heating systems.

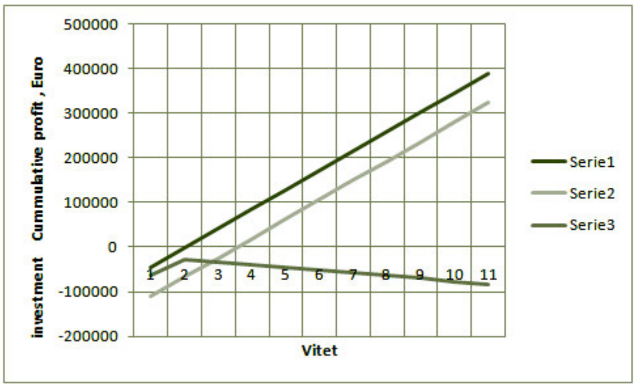

Fig. 7- The plots of the differences of yearly cumulative expenses for fuel and electric energy for the geothermal heat pumps for space heating and installation costs for different heating systems (in Euro).
Legend: Serie 1: Borehole-Geothermal Heat Pump system , Serie 2: Borehole-Heat Exchanger Geothermal Heat Pump system ; Serie 3: Boiler system.

Price of heating energy for the geothermal system results 3,45 Lek/kWh (0,0265 Euro/kWh) and 5,81 Lek/kWh (0,0446 Euro/kWh) respectively for Borehole-Geothermal Heat Pump system , Serie 2: Borehole-Heat Exchanger Geothermal Heat Pump system; in the same time for the boiler system the price results 16,9 Lek/kWh (0,13 Euro/kWh), consequently 4,9-2,9 time more expenses (fig. 8)

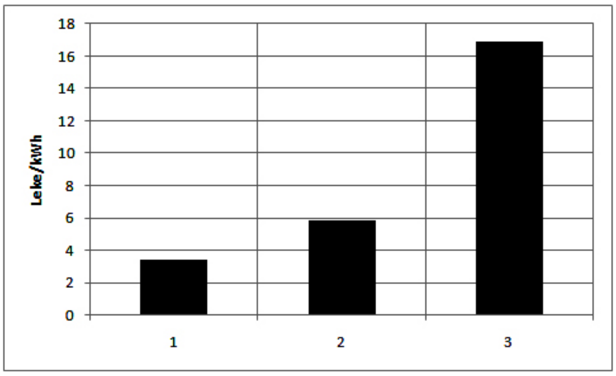

Fig. 8. Cost in Lek/kWh for space heating of the University of Korça building, for the payback period.
Legend: Serie 1: Borehole-Geothermal heat pump system , Serie 2: Borehole-Heat Exchanger Geothermal heat pump system ; Serie 3: Boiler system.

According to this analyze and graphics of the fig. 5-8, results that geothermal heating and cooling system is more economic system that boiler system.

6. CONCLUSIONS

a) The heating problem and its economic solution is an important task, taking into consideration the current severe energetic crises. One of the ways out is the use of geothermal energy. In Albania there are many high-rise building, which are still projected to include oil or gas fired boiler systems, as well as with air conditioning units. Air conditioning units heat all public institutions. The hospitals, dorms, hotels are heated by oil and gas fired boilers. It is the ripe time to move out of such practices, which do not provide for long term sustainable solutions to the heating and cooling problems in Albania.

b) Direct use of the geothermal energy for space heating/cooling can be contribute to improve country energy balance.

c) It is the right time to introduce systems using renewable energy shallow sources such as the geothermal energy: .

d) Geothermal space heating/cooling systems represent not only high economical efficiency but are environmental friendly.

Based on these conclusions, in the condition of the intensive building's construction in Albania and energetic crisis, are important two recommendations:

Firstly, the geothermal systems must have the priority for space heating/cooling of the new public and private buildings (industrial, and residential, etc.),

Secondly, the geothermal systems must have the priority during the re-construction of the heating/cooling systems of the hospitals, schools, dorms, hotels, etc., which are heated by oil and gas fired boilers.

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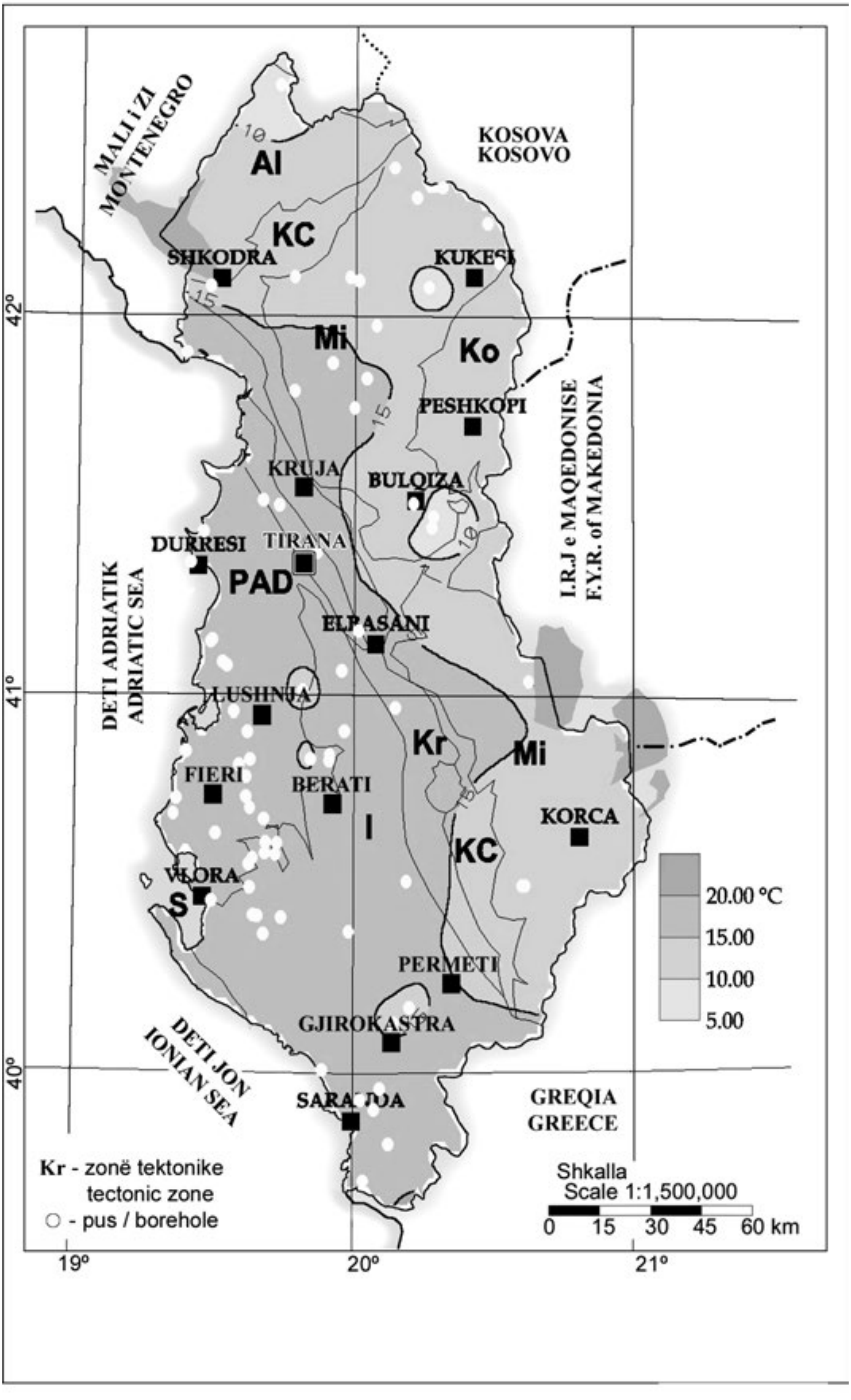


Fig. 2. Temperature map of Albania, at the depth 100 m

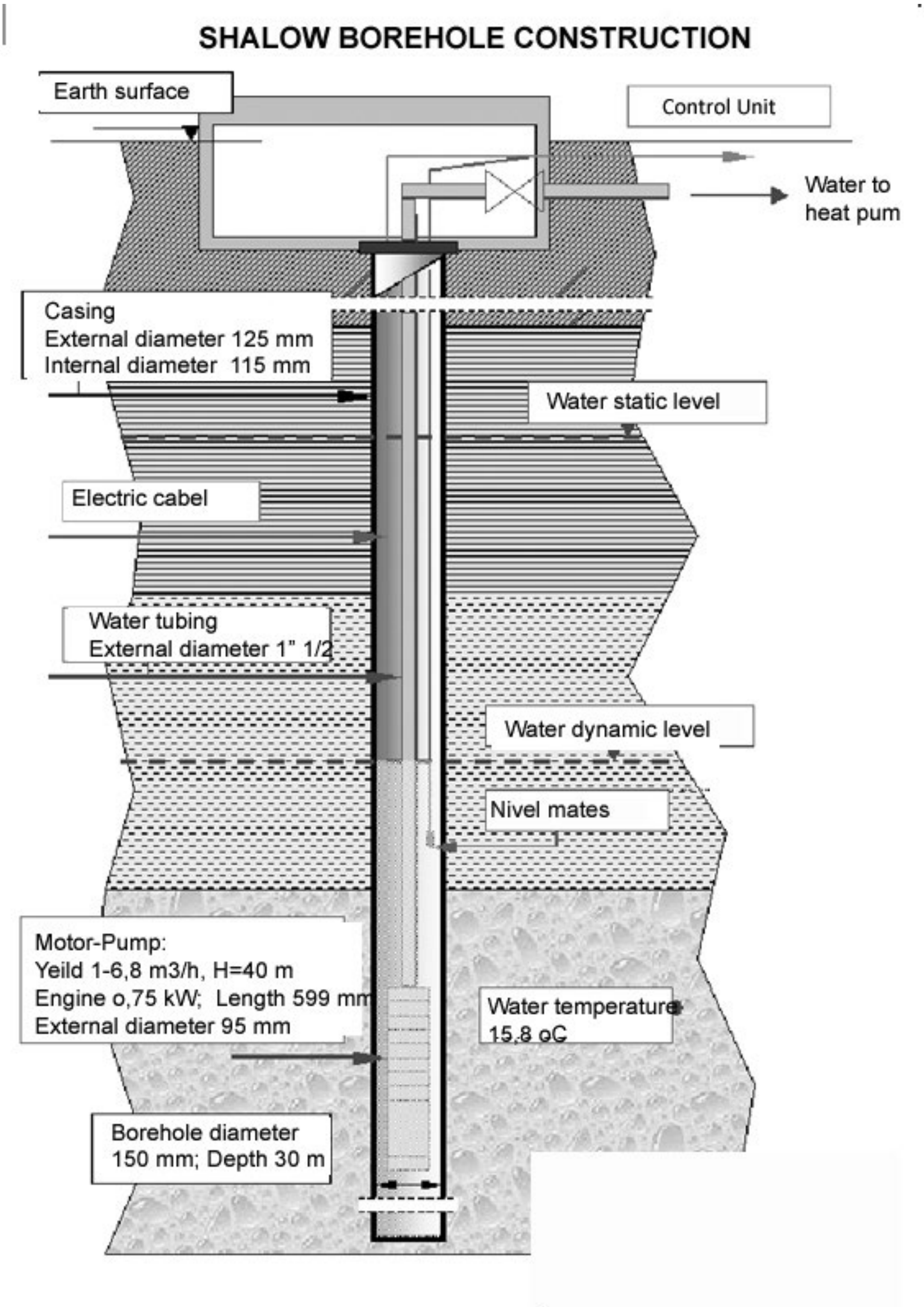


Fig. 4. Shallow Heat Source of Quaternary aquifer in Tirana Field region and borehole construction for water pumping to the Geothermal Heat Pump.

Introduction

The old problem of geophysical inversion (Lowrie 2009) continues to be a challenge despite the enormous progress done during several decades and recently with the use of parallel processing. Being a typically ill-posed problem (Hadamard 1902) it may give quite different solutions for the geosection for similar approximation of ground surface anomalies. Even in recent publications there are clear examples how geosection structure is significantly deformed including lack of contrast between bodies and non-existing syncline structures (Zhdanov et al 2010). Our work consisted on using simple algorithms for the gravity inversion and evaluating its performances in terms of runtime and quality of solutions (Frasheri and Cico 2012), (Frasheri and Bushati 2012), (Frasheri et al 2013).

Methodology

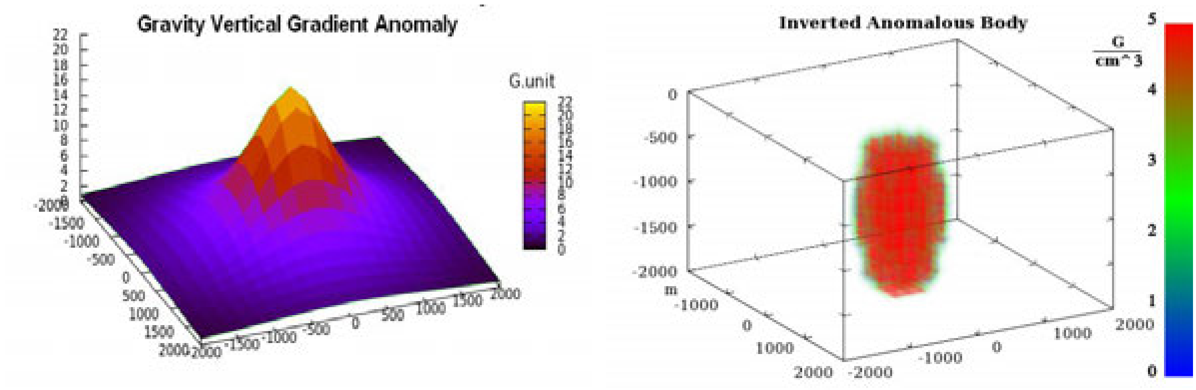
We used the princilpe of CLEAN algorithm (Högbom 1974) for our software GIM developed in FP7 project HP-SEE. We modeled a prismatic geosection as composed from an 3D array of cuboid elements represented by a 3D array of nodes where the mass of respective cuboids was concentrated. The ground surface represented by an 2D array of points situated at the upper face of the geosection. The algorithm starts with a distribution of masses zero in the geosection and iteratively updates the mass density of the cuboid element that best approaches the field anomaly, using a predefined mass density step; the effect of this update is subtracted from the field anomaly and the process is repeated based in the residual field anomaly.

A weigted least squares schema was used to evaluate the quality of approximation between two surfaces – the anomaly and the effect of a single 3D geosection element within a moving window over the 2D ground surface array. Firstly the window radius is defined based on the relative value of the effect of the 3D node in each of 2D points, with the radius \based on the relative effect of 3D node in each of 2D points greater than 1/W. Secondly, the same relative effect of 3D node in each of 2D points was used for weighting the least squares error. A third experiment was done considering in each iteration only 3D nodes directly under the 2D point where the residual field anomaly reaches its maximum. The termination of iterative process was tested with two different criteria: until the global least squares approximation error for the anomaly became less that a predefined small threshold; and until the calculated update of the mass density for the best 3D node became less than 1/2 of the predefined mass density step. Un-weighted global least squares error was calculated for the final evaluation of error approximation of the field anomaly and, for synthetic models, the error in the central cross-section of 3D geosections.

Experiments with synthetic models were done with a geosection 4000m*4000m*2000m discretized with 11x11x6, 21x21x11 and 41x41x21 nodes. Respective 2D arrays were used for the surface anomaly. Anomalous bodies were represented by vertical prisms with mass density varying in the range of 3 – 5 g/cm^3 were used. For each model, based on the respective discretization schema, the direct calculation was used to obtain the anomaly, which was used for the inversion. Two field cases were experimented, using maximal mass densities of 0.3 g/cm^3 and 5 g/cm^3.

Results and Discussions

The algorithm GIM gave good results for single body geosection models. The anomaly and inverted geosection for a single body model are presented in Fig. 1. The runtime dependence from the model size and the number of computing cores is presented in Fig. 2. Both parallelism technologies OpenMP and MPI gave similar results following the order of magnitude O(N^8). The scalability of number iterations followed the expected order of magnitude O(N^3). For two body geosection models the inversion of the anomaly, due to its shape with one “hill” with two peaks (Fig. 3), resulted deformed – the algorithm tended firstly to approximate the “hill” representing the global trend separating only the top of bodies.

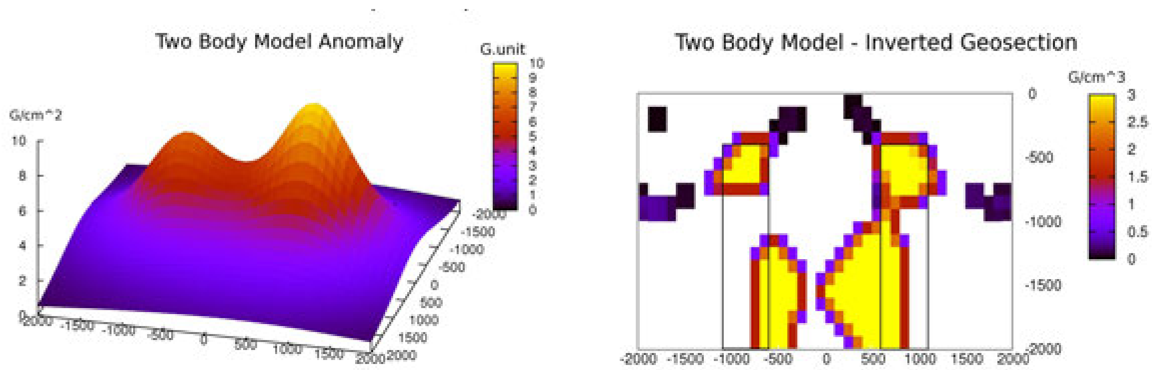


(a) (b)

Figure 1 *The single body inversion model: (a) gravity anomaly; (b) inverted body.*

(a) (b)

Figure 2 *Scalability of algorithm: (a) by number of computing cores; (b)by model size.*



(a) (b)

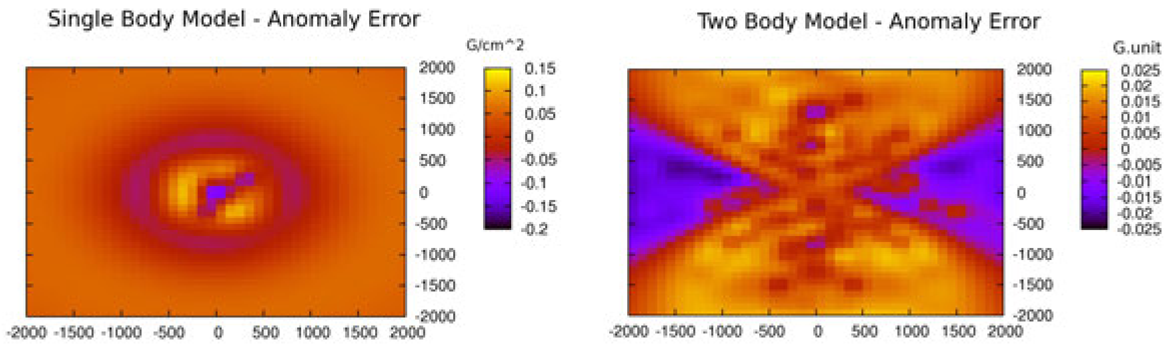
Figure 3 *The single body inversion model: (a) gravity anomaly; (b) inverted body.*

We obtained different inverted solutions using combinations of least squares schema for the same models. Compared with simple unconstrained least squares schema, constraints with windowing and weighting least squares gave relatively better results. A comparative analysis of errors for non-constrained versus constrained least squares schema for different models is presented in Fig. 4 for both anomalies and geosections. Errors resulted scattered and two categories partially blended with each other, which represented the instability of the solutions for the ill-posed inversion problem.

(a) (b)

__Figure 4__ The distribution of inversion errors represented by green rhomboids for constrained least squares schema, and red discs for non-constrained one: (a) single body model, (b) two body model.

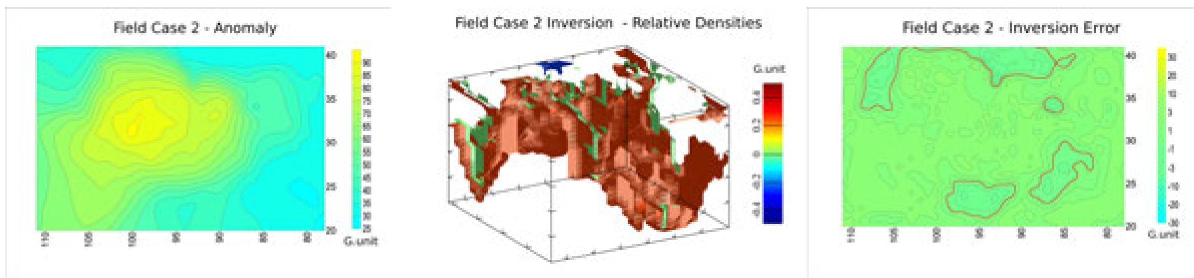
Spatial distribution of anomaly errors (Fig. 5) resulted clearly asymmetric for the two body models due to the deformation of inverted geosection lacking separation of in-depth anomalous bodies – the algorithm "preference" is a geosection with circular symmetry leading to asymmetric error distribution for anomalies created by geosections without circular symmetry.



(a) (b)

__Figure 4__ Spatial distribution of anomaly errors: (a) single body model, (b) two body model.

The results for a field case (Bouguer anomaly) are given in Fig. 5. Maximal mass density contrast of anomalous body with its surrounding is 0.3 g.cm^3



(a) (b) (c)

__Figure 5__ Inversion of a field case: (a) Bouguer anomaly, (b) inverted geosection, (c) anomaly error (red isolines represent zero values)

Conclusions

The use of constrained least squares error formula for calculation of the approximation of the residual anomaly by the effect of a single node of the 3D geosection gave an improved inversion solution for two body models. Two techniques used for constraining the error formula are based in the shape of the anomalous effect of a single node in different depths, constraining spatially the calculation within a circular window and including a weight based on the relative values of nodes' anomalies. The distribution of the errors had different patterns, making the determination of an unique methodology difficult. Reduction of inversion error with real field data would require a careful interpretation of the spatial distribution of the anomaly approximation error for identification of eventual patterns that indicate the deformation of inverted geosection structures. The algorithm works following the road to the best local approximation, which in multi-body structures may get locked in local optimums leading to wrong inverted geosections. Application of techniques for the disturbance of solutions may help to get unlocked from local optimums and improve the inversion.

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Geothermal Energy Resources in Albania-Country Update Paper

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ABSTRACT

Resources of Geothermal Energy of low enthalpy in Albania, and the platform for their direct use are presented in the paper.

Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters are sulfate, sulfide, methane, and iodinate-bromide types. Thermal sources are located in three geothermal zones:

Kruja geothermal zone represents a zone with bigness geothermal resources, in carbonate reservoirs.

Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs.

Peshkopia geothermal zone at northeastern area of Albania. Several springs are located with disjunctive tectonics of the gypsum diapir.

The geothermal situation in Albania offers three directions for the exploitation of geothermal energy:

Firstly, the use of the ground heat flow for space heating and cooling, by borehole heat exchanger-heat pumps systems.

Secondly, thermal sources of low enthalpy are natural sources or wells in a wide territory of Albania. They represent the basis for a successful use of modern technologies for a <u>*complex and cascade exploitation*</u> of this energy:

1. SPA clinics for treatment of different diseases and hotels for eco-tourism.
2. The hot water for heating and sanitary waters of the SPA and hotels, greenhouses and aquaculture installations.
3. From thermal waters it is possible to extract chemical microelements.

Thirdly, the use of deep abandoned oil and gas wells as "Vertical Earth Heat Probe".

1. INTRODUCTION

Geothermal Resources of Albania evaluation and platform for their use, are based on the results of more than two decades of geothermal studies.

- Geothermal Atlas of Albania and Atlas of geothermal resources in Albania (2004), have been performed in framework of the of the Committee for Sciences and Technology of Albania projects, by agreement between the Faculty of Geology and Mining, and the Geophysical Institute, Czech Acad. Sci., Prague, European Commission- International Heat Flow Commission (Frashëri A. 1992, Frashëri A. et al. 1994, 1995, 1996). Geothermal team of the Faculty of Geology and Mining, have been worked for the UNDP-GEF/SGP Tirana Office project (2003), and "Geothermal Resources of Albania and platform for their use", in the framework of the National Program for Research and Developing, Natural Resources, 2003-2005 (Frashëri A. et a. 2003, 2004, 2005). Has been published in electronic format the "Atlas of Geothermal Resources in Albania (Frashëri A. et. al. 2004).

Geothermal team from Faculty of Geology and Mining and Department of Energy of Faculty of Mechanical Engineering, during 2008 has worked for the Project: "Platform for integrated and cascade use of geothermal energy of low enthalpy in the framework of energetic balance of Albania", in the framework of the National Program for Research and Development, "Water and Energy" 2007-2009. Have been published a monograph: "Space Heating/Cooling Borehole-Vertical Heat Exchanger-Heat Pump System" (Frashëri A. et. al. 2008). In same time, we had prepared three project ideas: "Geothermal Center for integrated and cascade direct use of geothermal energy of Kozani-8 well, near Elbasani City" (spa-hotel with hot pools, greenhouse and aquacultyre instalations (spirulina and fisch), Project idea for space heating of Korça University using borehole-vertical heat exchanger-heat pump system, and project idea for set up of the "Geo-Energy Ressouces Laboratory" in the Department of Energy Reasources, Faculty of Geology and Mining (Frashëri A. et al. 2008, 2009). "Geothermal Resources of Albania and platform for their use", monograph, was published during 2010 by Faculty of Geology and Mining, Faculty of Mechanical Engineering, Polytechnic University of Tirana (Frashëri A. et Kodhelaj N., 2010).

The Promemory "Earth Heat is an alternative, environ friendly renewable energy, which is necessary to use

in Albania" has been addressed to the Albanian Government.

Periodically, results of the geothermal energy studies in Albania have been published and presented in International Symposiums, Conferences and Workshops.

In Albania there are many thermal water springs and wells of low enthalpy, with a temperature of up to 65.5°C, which indicates that there are possibilities for direct use of the geothermal energy. In Albania the new technologies of direct use of geothermal energy are either partly developed or remain still untouched. Integrated and cascade use of geothermal energy of low enthalpy will be represent an important direction for profitable investment. Exploitation of geothermal energy will have a direct impact in the development of the regions, by increasing their per capita income and at the same time ameliorating the standard of living of the people.

2. GEOLOGY BACKGROUND

The Albanides represent the main geological structures that lie on the territory of Albania. They are located between the Dinarides in the north and the Helenides in the south, and together they form the Dinaric Branch of Mediterranean Alpine Belt. Albanides are divided in two big peleogeographical zones: the Inner Albanides and the External Albanides. Korabi, Mirdita (ophiolitic belt), presents the Inner Albanides and Gashi zones. The Alps, the Krasta-Cukali, the Kruja, the Ionian zone, the Sazani zone and the Pre-Adriatic Depression present the External Albanides. Depression as a part of Albanian Sedimentary Basin continued towards the shelf of the Adriatic Sea. The geological cross-section of Albanian Sedimentary Basin is about 15 km thick and it continues also in the Adriatic Sea Shelf.

Ionian zone is developed as a large pelagic trough in the Upper Triassic. There, the evaporites of the Permian-Triassic are overlapped by a thick carbonate formation of the Upper Triassic-Eocene. The geological section on this carbonate formation is covered by Oligocene flysch, a flyschoid formation of the Aquitanian and by schilieres of the Burdigalian, Helvetian and particularly of Serravalian- Tortonian molasses. Burdigalian deposits are overlapped transgressively with an angular unconformity, anticline belts. The Tortonian Age deposits have filled the synclinal belts of Ionic and Kruja tectonic zones.

Miocene and Pliocene molasses of Peri-Adriatic Depression overlies the structures of northern part of the Ionian zone. The structure of Neogene molasses represents the upper tectonic stage of the structure of the Peri-Adriatic Depression.

In the over part of the section of Kruja zone, the carbonate neritic rocks of the Cretaceous-Paleogene age are overlying the Oligocene flysch of a thickness of 5 km.

The structures of the Albanides are typically Alpine ones. The SSE-NNW directions represent their general strike. The structures are asymmetrical and have a western vengeance. Recumbent, overthrusted and overtwisted structures are found, too. Generally, their western flanks are affected by disjunctive tectonic.

3. METHODS AND STUDY AREA

Geothermal studies carried out in Albania are oriented toward the study of the distribution of the geothermal field and the natural thermal water springs and wells. Geothermal studies were extended all over the country territory.

The temperatures have been measured and the geothermal gradient and the heat flow density at different depths have also been calculated (Frasheri et al. 1995). Temperature measurements were carried out both in 145 deep wells, in boreholes and in mines, at different hypsometric levels. The temperature in the wells was recorded at regular intervals. It was measured by means of resistance and thermistor thermometers. The average absolute measurement error was 0.3°C. The measurements were carried out in a steady-state regime of the wells filled with mud or water. The recorded data were processed using the trend analysis of first and second degrees. The chemical composition of the waters was found. The output of the springs and wells and their hydrogeology was evaluated.

4. RESULTS

4.1. Geothermal Regime

The Geothermal Regime of the Albanides is conditioned by tectonics of the region, lithology of geological section, local thermal properties of the rocks and geological location (Frasheri A. 1992, Frasheri et al. 1994, 1995, 2004, 2010).

4.1.1. Temperature

The geothermal field is characterized by a relatively low value of temperature. The temperature at 100 meters depth varies from less than 10 to almost 20°C, with lowest values in the mountain regions. The temperature is 105.8°C at 6000 meters depth, in the central part of the Peri-Adriatic Depression. The isotherm runs parallel the Albanides strike (Fig. 1). Going deeper and deeper the zones of highest temperature move from southeast to northwest, towards the center of the Peri-Adriatic Depression and even further towards the northwestern coast. The temperatures in ophiolitic belt are higher than in sedimentary basin, at the same depth.

4.1.2. Geothermal Gradient

In the External Albanides the geothermal gradient is relatively higher. The geothermal gradient displays the highest value of about 21.3 $mK.m^{-1}$ in the Pliocene clay section in the centre of Peri-Adriatic Depression. The largest gradients are detected in the anticline molasses structures of the center of Pre-Adriatic

Depression (Fig. 5). The gradient decreases about 10-29% where the core of anticlines in Ionic zone contains limestone. The lowest values of 7-11 $mK.m^{-1}$ of the gradient are observed in the deep synclinal belts of Ionic and Kruja tectonic zones (Fig.2).

In the ophiolitic belt of the Mirdita tectonic zone, the geothermal gradient values increase up to 36 $mK.m^{-1}$ at northeastern and southeastern part of the Albania.

4.1.3. Heat Flow Density:

Regional pattern of heat flow density in Albanian territory is presented in the Heat Flow Map. There are observed two particularities of the scattering of the thermal field in Albanides (Fig. 3):

Firstly, maximal value of the heat flow is equal to 42 mW/m^2 in the center of Peri-Adriatic Depression of External Albanides. The 30 mW^{-2} value isotherm is open towards the Adriatic Sea Shelf. These phenomena have taken place owing to the great thickness of sedimentary crust, mainly carbonate one in this zone.

Secondly, in the ophiolitic belt at eastern part of Albania, the heat flow density values are up to 60 mW/m^2. The contours of Heat Flow Density give a clear configuration of ophiolitic belt. Radiogene heat generation of the ophiolites is very low. In these conditions, increasing of the heat flow in the ophiolitic belt, is linked with heat flow transmitting from the depth. The granites of the crystalline basement, with the radiogenic heat generation, represent the heat source.

4.2. Geothermal energy resources in Albania

Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters with a temperatures that reach values of up to 65.5°C are sulfate, sulfide, methane, and iodinate-bromide types (Frasheri A. et al. 1996, 2004, 2010) (Tab. 1, Fig.4). In many deep oil and gas wells there are thermal water fountain outputs with a temperature that varies from 32 to 65.5°C (table 2, Fig. 3)

Albanian geothermal areas have different geologic and thermo-hydrogeological features. Thermal sources are located in three geothermal zones (fig. 4):

Kruja geothermal zone represents a zone with bigness geothermal resources. Kruja zone has a length of 180 km. Kruja Geothermal Zone is extended from Adriatic Sea at North and continues in South-Easter area of Albania and in Konitza area in Greece. Photo 1 shows Lëngarica - Përmet thermal springs at southern Albania. Identified resources in carbonate reservoirs in Albanian side are $5.9x10^8$-$5.1x10^9$ GJ. The most important resources, explored until now, are located in the Northern half of Kruja Geothermal Area, from Llixha-Elbasan in the South to Ishmi, in the North of Tirana. The values of specific reserves vary between 38.5-39.63 GJ/m^2.

Kruja geothermal area represents an anticline structure chain with carbonate core of Cretaceous-Eocene age. They are covered with Eocene- Oligocene flysch. Anticlines are linear with as length of 20-30 km. They are asymmetric and their western flanks are separated from disjunctive tectonics. Geothermal aquifer is represented by a karstified neritic carbonate formation with numerous fissures and micro fissures.

In the Ishmi area, Ishmi 1-b well has been drilled in 1994. It is situated in the top part of the limestone structure. It is located 20 km North- West of Tirana, in the plain area, near “Mother Theresa” Tirana airport. It meets limestone at 1300m of depth and goes through a carbonate coupe of 1016 m thickness.

Kozani 8 well has been drilled in 1989 (Photo 2). It is situated 35 km South- East of Tirana and 8 km North-West of Elbasani. It is situated on hills close to Tirana-Elbasani national road. It meets limestone at 1810m of depth and goes 10m deep in them.

Since the end of the drilling to this day hot water continues to fountain from Ishmi 1-b and Kozani 8 wells.

Elbasani Llixha watering place is about 12 km South of Elbasani. There are seven spring groups that extend like a belt with 320^o azimuth. All of them are connected with a the main regional disjunctive tectonics of Kruja zone. Thermal waters flow out through the contact of conglomerate layer with calcolistolith. In this area too, the reservoir is represented by the Llixha limestone structure. These springs have been known before Second World War.

Surface water temperatures in the Tirana-Elbasani zone vary from 60° to 65.5°. In the aquifer top in the well trunk of Kozani 8 temperature is 80°C. Hot water is mineralized, with a general mineralization of 4.6-19.3 g/l. Elbasani Nosi Llixha water has the following formula:

$$H_2S_{0.403}M_{7.1}\frac{Cl_{59}SO_{38}^{4}}{Na_{46}Ca_{35}}$$

Peshkopia geothermal zone is situated in the Northeast of Albania. Two kilometers East of Peshkopia some thermal springs are situated very close to each other. These thermal springs flow out on Banja river slope. These springs are linked with the disjunctive tectonic seismic-active zone Ohrid Lake-Debar, at periphery of gypsum diapir of Triassic age that has penetrated Eocene flysch which surround it like a ring. The occurrence of thermal waters is connected with the low circulation zone always under water pressure. They are of sulfate-calcium type, with a mineralization of up to 4.4 g/l, containing 50 mg/l H_2S. Their chemical formula is:

$$H_2S_{0.0495}M_{4.4}\frac{SO_{56}^{4}}{Ca_{65}}$$

Yield of some of the springs goes up to 14 l/sec. Water temperature is 43.5 °C.

Water temperature and big yield, stability, and also aquifer temperature of Peshkopia Geothermal Area similar are with those of Kruja Geothermal Area. For this reason geothermal resources of Peshkopia Area have been estimated to be similar to those of Tirana-Elbasani area.

Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs.

5. PLATFORM FOR THE DIRECT USE OF GEOTHERMAL ENERGY OF LOW ENTHALPY IN ALBANIA

The geothermal situation of low enthalpy in Albania offers three possibilities for the direct use of geothermal waters energy. Geothermal energy exploitation must be realized by integrated scheme of geothermal energy, heat pumps and solar energy, and cascade use of this energy (Frashëri A. 2001, Frasheri A. et al. 2003, 2004, 2008,2009, 2010).

Firstly, the Ground Heat can be use for space heating and cooling by Borehole Heat Exchanger-Geothermal Heat Pumps modern systems. At the present in Albania have been installed geothermal heating systems in six buildings in different cities: Tirana, Korça, Shkodra, Erseka.

Secondly, thermal sources of low enthalpy and of maximal temperature up to 65.5°C.

Thermal waters of springs and wells may be used in several ways:

1. Modern Wellness SPA for treatment and healing of different diseases, recreation, thermal physical and mental relaxation, with thermal bath and pools, sauna, massages, fitness and activities for development of eco-tourism. Such centers may attract a lot of clients not only from Albania, because the good curative properties of waters and springs are situated at nice places, near seaside, Gjinari Mountain or Ohrid Lake pearl.

The oldest and important is Elbasani Llixha SPA is located in Central Albania. By national road communication, Llixha area is connected with Elbasani. These thermal springs from about 2000 years ago are known, near of the old road “Via Egnatia" that has passed from Durresi-Ohrid- to Constantinople. All seven groups of the springs in Llixha Elbasani and Kozani-8 well, near of Saint Vladimir Monastery at Elbasani, have the possibilities for modern complex exploitation. Ishmi 1/b geothermal well is located in beautiful Tirana field, near of Mother Theresa- Tirana Airport, near of the Adriatic coastline and Kruja - Skanderbeg Mountain.

Peshkopia SPA was constructed by modern concepts as balneological geothermal center. There are thermal pools, for medical treatment and recreation. Construction of the Peshkopia SPA must been good example for new SPA construction in Albania.

2. The hot water can be used also for heating of hotels, SPA and tourist centers, as well as for the preparation of sanitary hot water used there.

3. Near thermal water springs and wells it is possible to build the greenhouses for flowers and vegetables, asparagus cultivation, etc.

4. Aquaculture installations for cultivation of the micro-alga as spirulina etc. for alimentary industry, preparation of pomades, and fiches cultivation will be other profitable activities.

5. From thermal mineral waters it is possible to extract very useful chemical microelements as iodine, bromine, chlorine etc. and other natural salts, so necessary for preparation of pomades for the treatment of many skin diseases as well as for beauty treatments. From these waters it is possible to extract sulphidric and carbonic gas.

6. Scientific research for study of the possibility of generating electricity from geothermal sources of low enthalpy, about 80^{o}C, as good local energy sources and provides a secure domestic energy supply with stable output.

Thirdly, the use of deep doublet abandoned oil and gas wells and single wells for geothermal energy, in the form of a “Vertical Earth Heat Probe”. The geothermal gradient of the Albanian Sedimentary Basin has average values of about 18.7 $mK \cdot m^{-1}$. At 2 000 m depth the temperature reaches a value of about 48°C. In these single abandoned wells a closed circuit water system can be installed. Near of these wells, can be build greenhouses.

Actually in Albania is prepared a platform with scenarios for integrated and cascade use of the geothermal energy, in the framework of the National Program for Research and Development, Water and Energy (2007-2009). Based on complex analysis, for the best area selected according to the scenarios, a Feasibility Study is performed to analyze three components: energy supply, environmental impact and financial aspects, and to suggest the best solution of the innovative geothermal energy utilization technology applications in that area.

Consequently, the sources of low enthalpy geothermal energy in Albania, which are at the same time the sources of multi-element mineral waters, they represent the basis for a successful use of modern technologies for a *complex and cascade exploitation* of this environmental friendly renewable energy, achieving a economical effectiveness. Such developments are useful also for the creation of new working places and improvement of the level of life for local communities near thermal sources.

6. CONCLUSIONS

1. Albania has geothermal energy resources, which can be direct use as alternative, environmental friendly energy.

2. Resources of the geothermal energy in Albania are;

- Natural springs and deep wells with thermal water, of a temperature up to 65.5°C.
- Heat of subsurface ground, with an average temperature of 16.4^{o}C and depth Earth Heat Flow.

3. Construction of the space-heating system, based on direct use of ground heat, by using of the shallow borehole heat exchanger (BHE)-Heat Pumps systems, is actually most important direction of the use of geothermal energy.

7. ACKNOWLEDGMENTS

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THERMAL WATER SPRINGS IN ALBANIA

Tab. 1

N° of Springs	Location	Temperature in ℃	Salt in mg/l	Artesian Spring yield in l.s-1
1	Llixha Elbasan	60	6,3	15-18
2	Peshkopi	5-43	4,2	23
3	Lëngarica-Permet	6-31	1,65	>10
4	Sarandoporo-Leskovik	26,7	1,2	>10
5	Tervoll-Gramsh	24	2,5	>10
6	Mamurras-Tirane	21	5,4	>10
7	Steam Postenani springs			

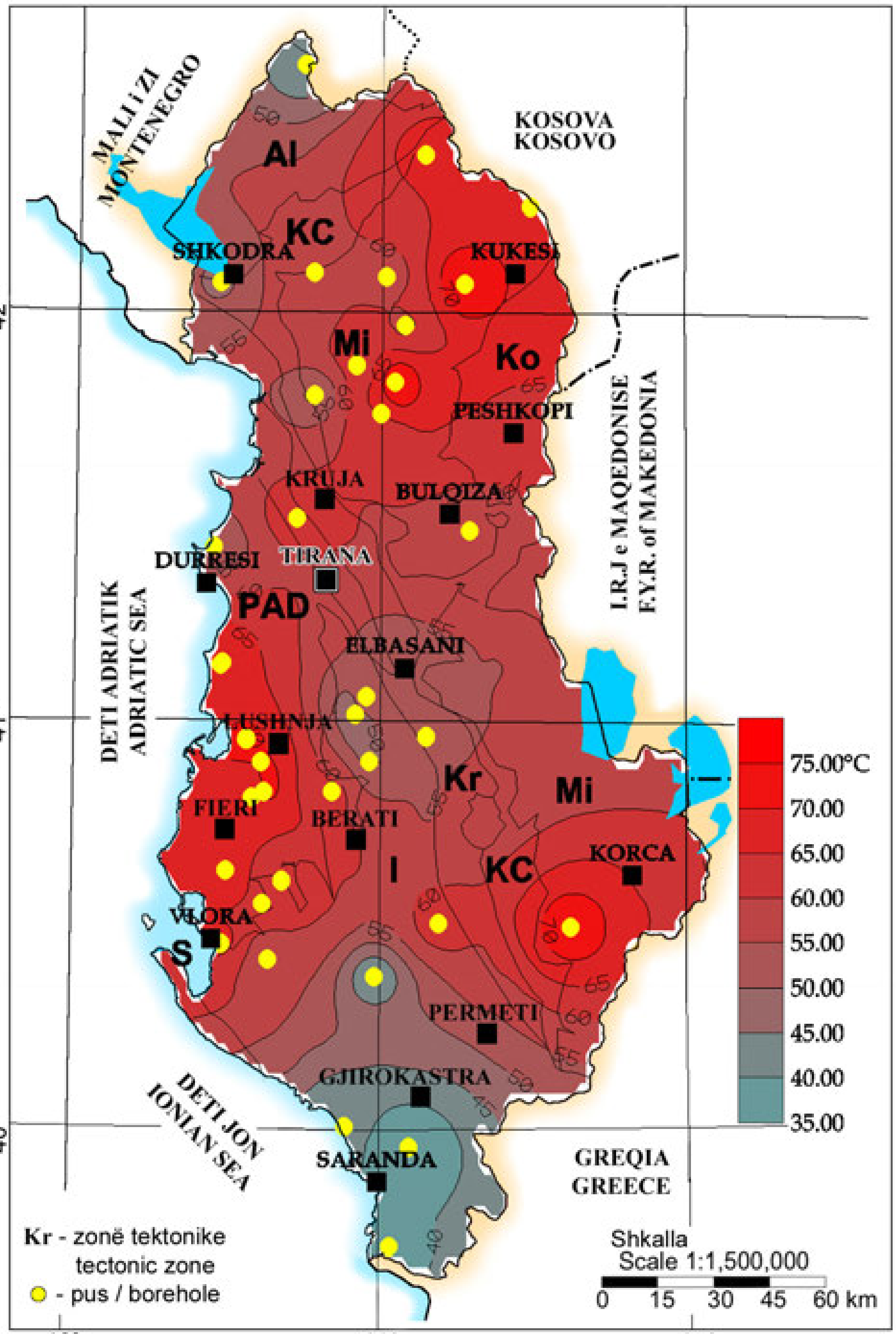
THE OIL AND GAS WELLS THAT HAVE SELF-DISCHARGE OF THE THERMAL WATER

Tab. 2

N°	Well Name	Temperature in ℃	Salt in $mg.l^{-1}$	Self-discharge in $l.sec^{-1}$
1	Kozani	65.5	4,6	10,4
2	Ishmi	64	15	4,4
3	Shupal-Tirana	29.5	1,6	1,6
4	Galigati	45-50	5,7	0,9
5	Bubullima	48-50	35	
6	Ardenica 3	38	38,2	15-18
7	Ardenica 12	32	53,6	5-18
8	Semani 1	35		5
	Semani 3	67	20,7	30
9	Verbasi	29.3	8,2	1-3

Photo 1. Langarica-Permeti thermal water springs

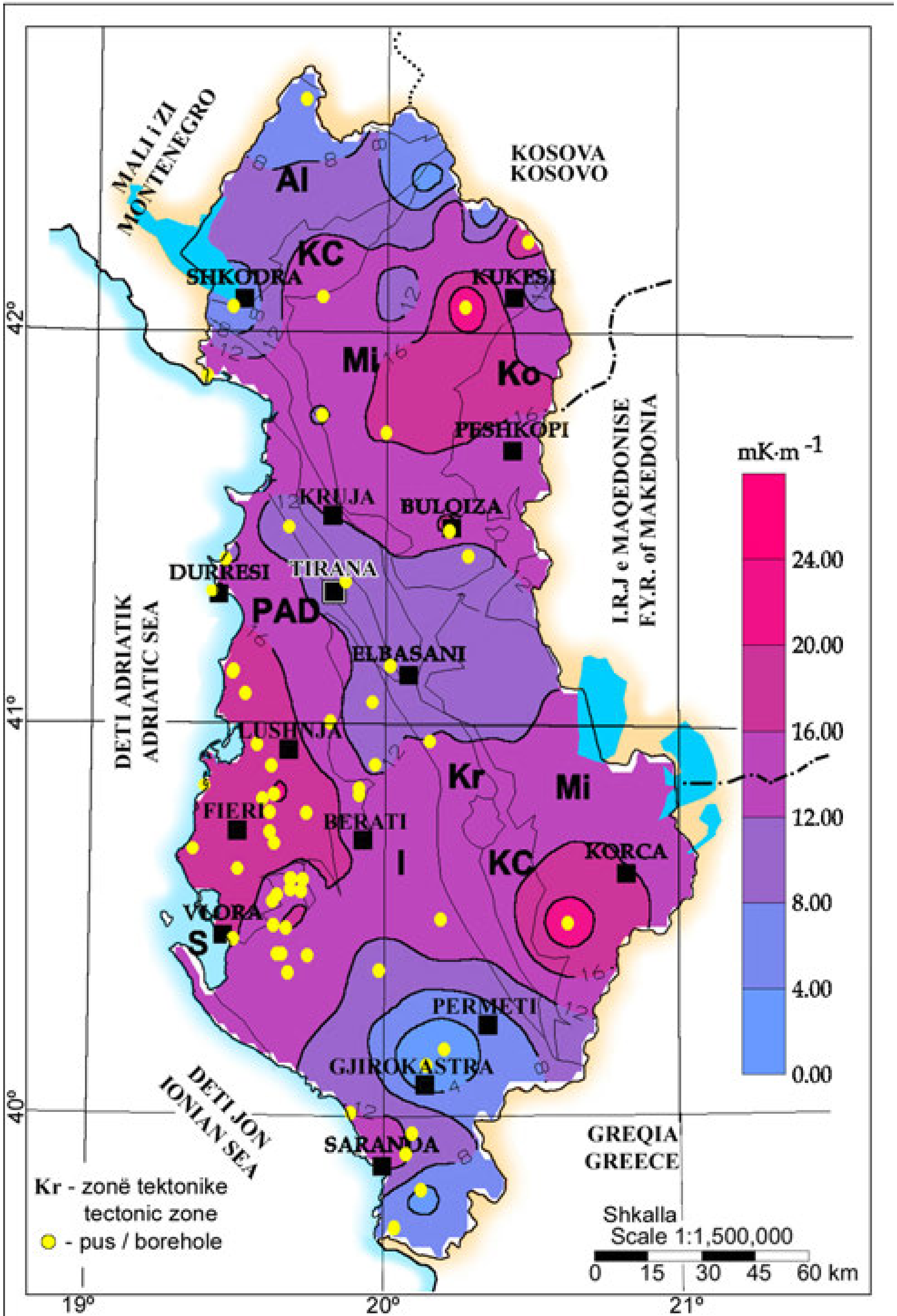
Photo 2. Geothermal deep well Kozani - 8



Harta e temperaturës në thellësinë 3000m
Temperature Map at the depth 3000m

Fleta / Plate 12

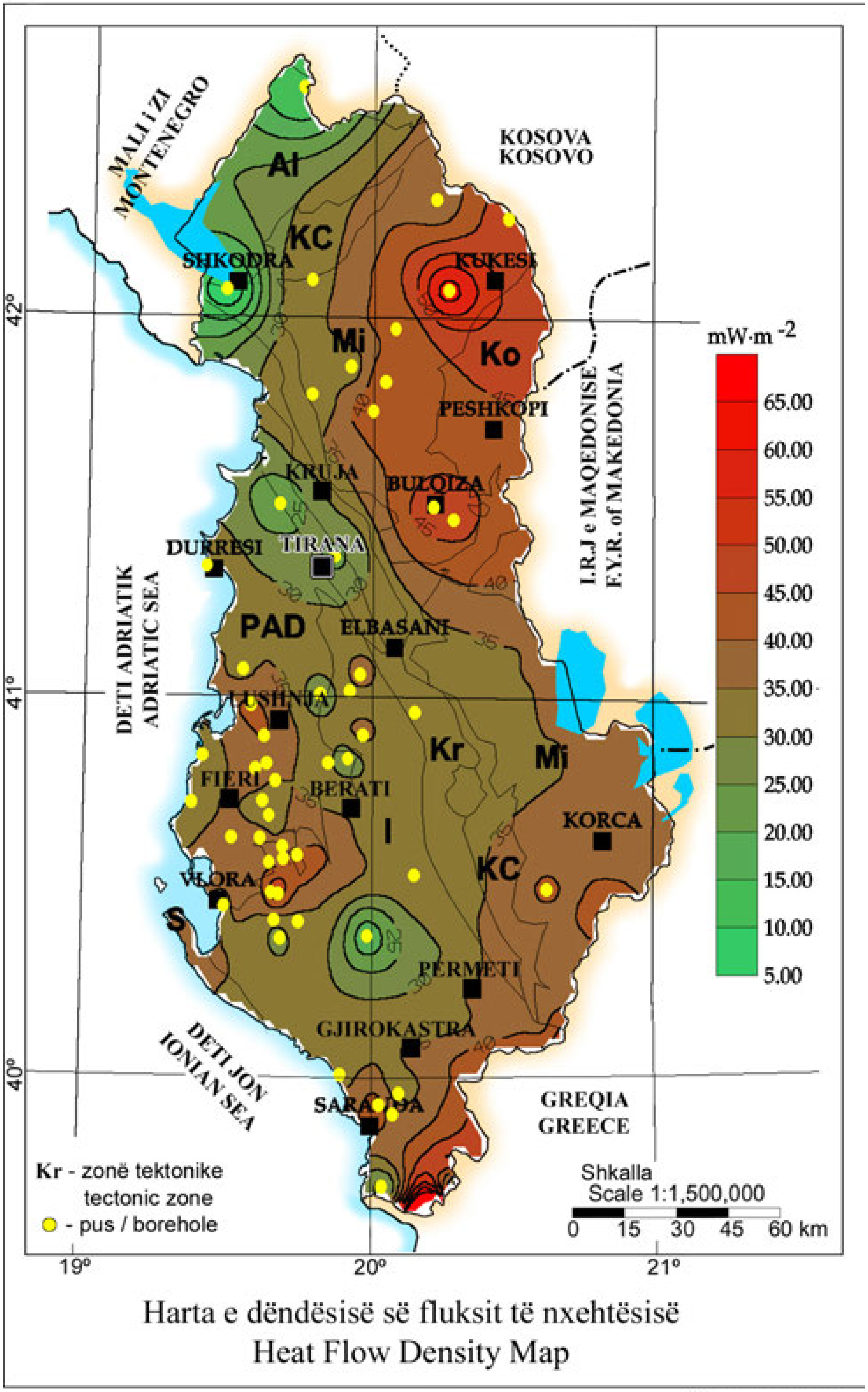
Fig. 1



Harta e gradientit gjeotermal mesatar
Average Geothermal Gradient Map

Flet

Fig. 2


MALI i ZI
MONTENEGRO
KOSOVA
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SHKODRA
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DURRESI
TIRANA
PAD
ELBASANI
LUSHNJA
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FIERI
BERATI
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KORCA
KC
VLORA
S
PERMETI
GJIROKASTRA
SARANDA
GREQIA
GREECE
I.R.J e MAQEDONISE
F.Y.R. of MAKEDONIA
DETI ADRIATIK
ADRIATIC SEA
DETI JON
IONIAN SEA
mW·m -2
65.00
60.00
55.00
50.00
45.00
40.00
35.00
30.00
25.00
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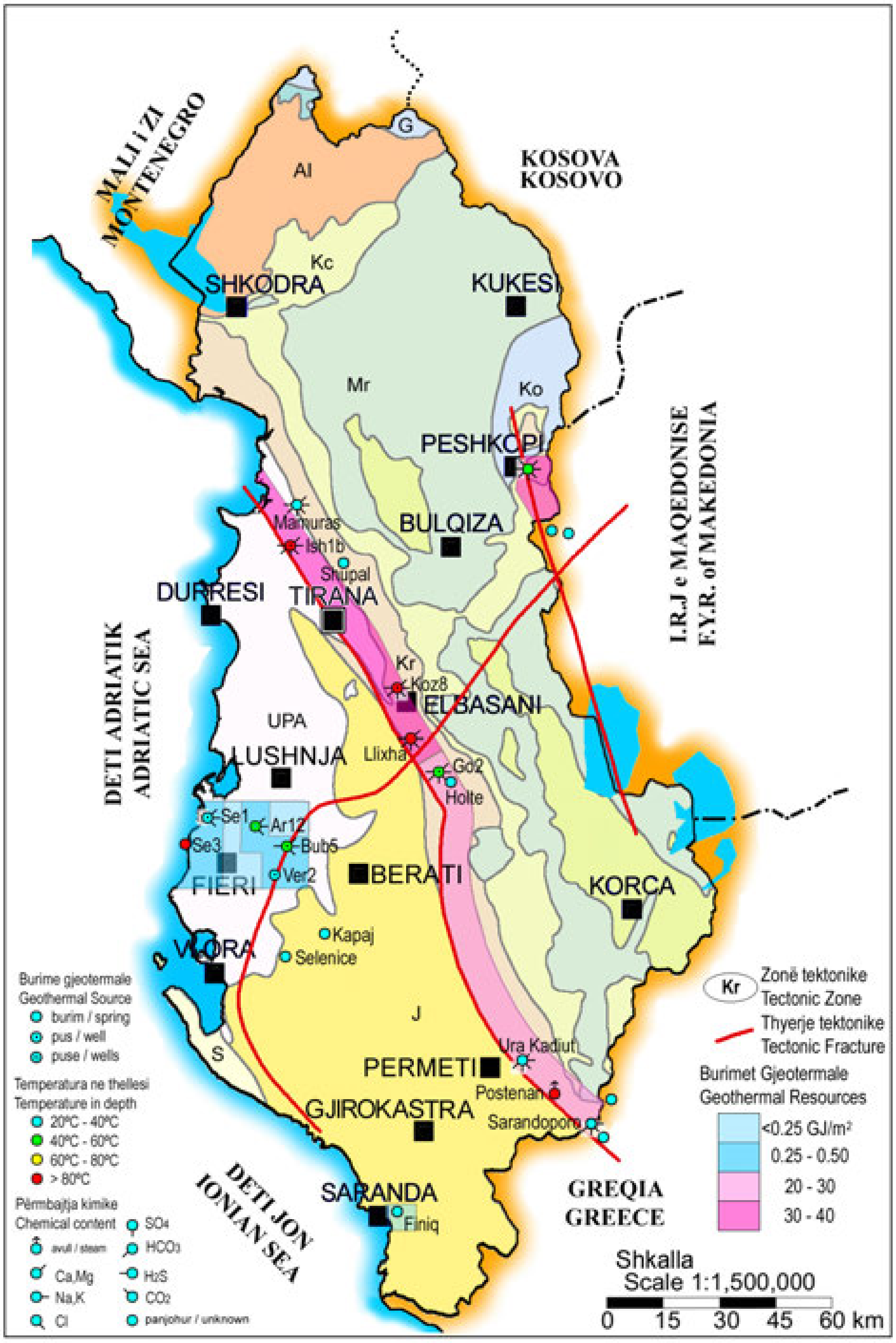
15.00
10.00
5.00
Kr - zonë tektonike
tectonic zone
- pus / borehole
Shkalla
Scale 1:1,500,000
0 15 30 45 60 km
19°
20°
21°
42°
41°
40°
Harta e dëndësisë së fluksit të nxehtësisë
Heat Flow Density Map
Fle

Fig. 3



Harta tematike gjeotermale
Geothermal Thematic Map

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Fig. 4

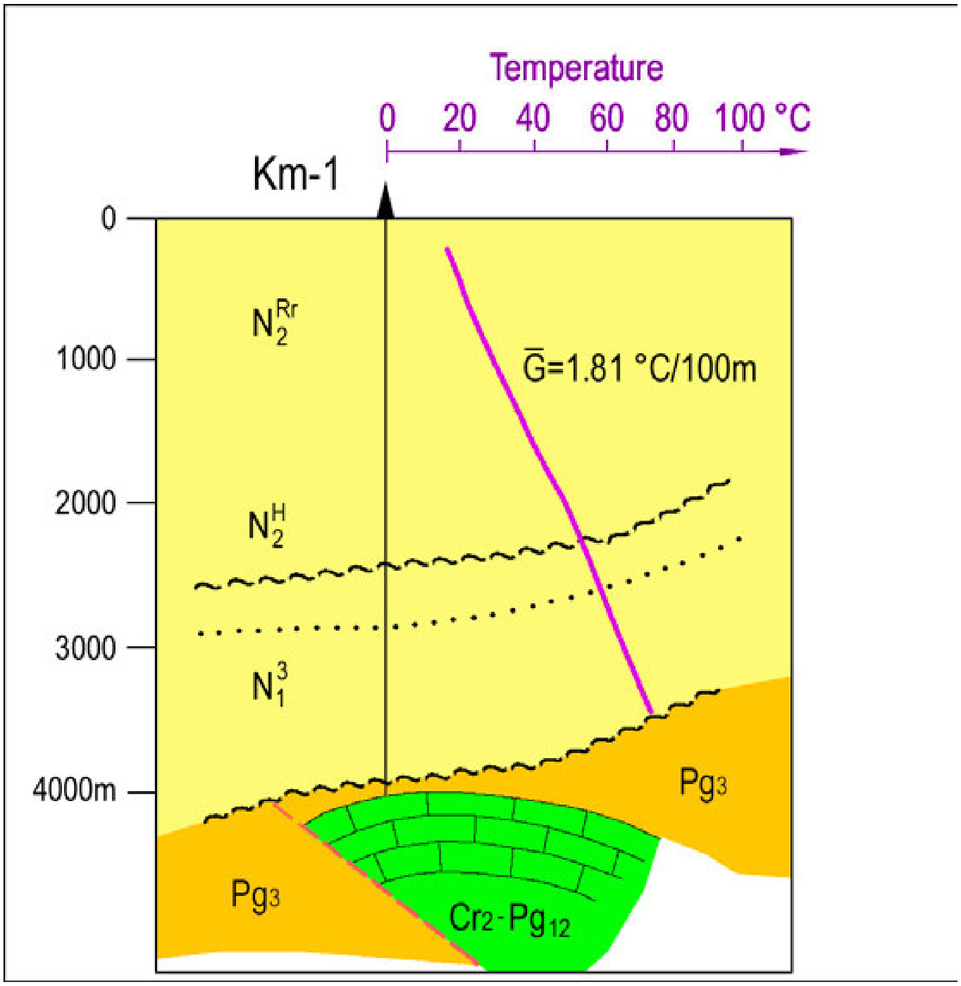

Fig. 5 - Geothermal Section Peri-Adriatic Depression

Tables A-G

Table A: Present and planned geothermal power plants, total numbers

	Geothermal Power Plants		Total Electric Power in the country		Share of geothermal in total	
	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (%)	Production (%)
In operation end of 2012						
Under construction end of 2012						
Total projected by 2015	---	---	---	---	---	---

Table B: Existing geothermal power plants, individual sites

Locality	Plant Name	Year commiss.	No of units	Status	Type	Total inst. Capacity (MW_e)	Total run-ning cap. (MW_e)	2012 product. (GWh_e/y)
total		**---**	**--**	**---**	**---**	**---**	**---**	**---**

Key for status:		Key for type:			
O	Operating	D	Dry Steam	B-ORC	Binary (ORC)
N	Not operating (temporarily)	1F	Single Flash	B-Kal	Binary (Kalina)
R	Retired	2F	Double Flash	O	Other

Table C: Present and planned geothermal district heating (DH) plants and other direct uses, total numbers

	Geothermal DH Plants		Geothermal heat in agriculture and industry		Geothermal heat in balneology and other	
	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (TJ/yr)
In operation end of 2012					11.728	
Under construction end of 2012					---	---
Total projected by 2015	---	---	---	---	11.728	8.45

Table D: Existing geothermal district heating (DH) plants, individual sites

Locality	Plant Name	Year commiss.	Is the heat from geo-thermal CHP?	Is cooling provided from geo-thermal?	Installed geotherm. capacity (MW_{th})	Total installed capacity (MW_{th})	2012 geo-thermal heat prod. (GWh_{th}/y)	Geother. share in total prod. (%)
total		**---**	**---**	**---**	**---**	**---**	**---**	**---**

Table E: Shallow geothermal energy, ground source heat pumps (GSHP)

	Geothermal Heat Pumps (GSHP), total			New GSHP in 2012		
	Number	Capacity (MW_{th})	Production (TJ/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2012	106	1.936	9.075	---	---	---
Projected by 2015	---	---	---	---	---	---

Table F: Investment and Employment in geothermal energy

	in 2012		Expected in 2015	
	Investment (million €)	Personnel (number)	Investment (million €)	Personnel (number)
Geothermal electric power	---	---	---	---
Geothermal direct uses	Not data	Not data	Not data	Not data
Shallow geothermal	Not data	Not data	Not data	Not data
total	Not data	Not data	Not data	Not data

Table G: Incentives, Information, Education

	Geothermal el. power	Geothermal direct uses	Shallow geothermal
Financial Incentives – R&D	---	DIS	DIS
Financial Incentives – Investment	---	LIL	DIS
Financial Incentives – Operation/Production	---	LIL/LIL	LIL/LIL
Information activities – promotion for the public	Not any activity	Yes brochures, books, video, leaflets, papers in newspapers.	Yes brochures, books, video, leaflets, papers in newspapers.
Information activities – geological information	Yes analyses related to the possibilities of power generation in Albania, used binary systems.	Yes geothermal and hydrochemical studies of the thermo-mineral waters in Albania of springs and deep wells.	Yes geothermal and hydrogeological studies related to the shallow geothermal in Albania.
Education/Training – Academic	Geothermal Energy use is included in the university curricula in different Faculties.	Geothermal Energy use is included in the university curricula in different Faculties.	Geothermal Energy use is included in the university curricula in different Faculties.
Education/Training – Vocational	Not	Not	Not

Key for financial incentives:					
DIS	Direct investment support	RC	Risk coverage	FIP	Feed-in premium
LIL	Low-interest loans	FIT	Feed-in tariff	REQ	Renewable Energy Quota

platform for the direct use of geothermal energy of low enthalpy in albania

PECULIARITIES OF THE ULTRABASIC ROCK MAGNETISM AND PALEOMAGNETISM DATA OF ALBANIDES OPHIOLITE

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Abstract

In Albania was gained a good experience for the geophysical exploration of chrome, copper and other solid mineral deposits, which are concentrated in the ophiolitic formation. For their exploration have been performed integrated geological-geophysical and geochemical ground and underground surveys. The geophysical complex for exploration was included gravity, magnetic and IP surface mapping at different scales, and the electrical and underground surveying. Underground surveying was carried out for the search around mine works and bore holes. In order to get the geophysical documentation of the boreholes, are observed the magnetic field, the gravitational field, the IP, the electromagnetic waves, the scattered gamma radiation and the neutron activation. In the complex of geophysical exploration are included gravitational and magnetic regional mapping at different scales and petrophysical studies, including density, magnetisation, electrical resistivity, induced chargeability, and radioactivity of ores and rock formations.
In this paper are generally presented the peculiarities of the ophiolite magnetization in condition of Alpine Folded Belt, especially pale magnetic studies results in Albania.

1. Introduction

In the paper are presented the peculiarities of the ophiolite formation magnetization in condition of Alpine Folded Belt, including paleomagnetic studies results in Albania. In Albania was gained a good experience for the geophysical exploration of chrome, copper and other solid mineral deposits, which are concentrated in the ophiolitic belt. For their exploration carried out integrated geological-geophysical and geochemical ground and underground surveys. The geophysical complex for exploration includes gravity, magnetic and IP surface mapping at different scales, and the electro-magnetic underground survey. Underground survey was carried out for the search around mine works and bore holes. In order to get the geophysical documentation of the boreholes has been used their well logging: electric, electro-magnetic, gamma, gamma-gamma, and radioactive logging, and magnetic surveys. Important part of the complex of geophysical direct explorations are included gravitational and magnetic regional mapping at different scales and petrophysical studies, including density, magnetism, electrical resistivity, induced chargeability, and radioactivity of ores and rock formations.

2. Study methodic

Study of magnetism of the rock is conducted by measurements of the magnetic susceptibility in outcrops in the field and induced and remnant magnetization determination in the samples collected in rocks of different formations from all Albanides ophiolite massifs. Sampling for the paleomagnetic studies have been carried out in fresh ultrabasic rocks, in gabbro, and in volcanic rocks of the Mirdita tectonic zone during 1995 year (Frashëri A, and Bushati S. 1995). Have been determined space orientation of the vector of magnetic magnetization, and for representative samples carried out thermal cleaning and demagnetization in the magnetic field of the alternative electric current. Sampling sites were located in six characteristic profiles on ophiolitic missives from south to the northern Albania. Magnetic properties of the rocks have been determined in Geophysical Chair, Faculty of Geology and Mining, Polytechnic University of Tirana, and Geophysical-Geochemical Center of Tirana. Paleomagnetic samplings were carried out by their joint team. Paleomagnetic determinations were performed in Paleomagnetic Laboratories of Leoben University, Austria, Aristotle University of Thessaloniki, Greece, and Institute of Geophysics, Academy of Sciences, Prague.

3. Results analyse

The ophiolite formation, with two ultramaphic massifs belt extends in the territory of Mirdita tectonic zone of the Albanides. The eastern ultramaphic belt has two different geological-petrological-geochemical and metallogenic sequences: tectonic sequence in lower part of geological cross-section in about 1000 - 2000m thickness and that of cumulate sequence, over tectonic one, is about 500 - 1000m thickness (Fig. 1, 2) . The lower part of tectonic sequence represents the hartzburgite facies with dunitic alternation, composed of fresh rocks in the lower levels up to medium serpentinized rocks in upper levels. The dunites represent lenses of thickness of some meters, stretching over hundreds of meters. These alternations represent 10-15 % of the rock mass. A narrow alternated hartzburgite-dunitic facie, with metallurgic chromite, is situated over the hartzburgite. The cumulate sequence is situated with angular unconformity over tectonite (petrological MOHO).

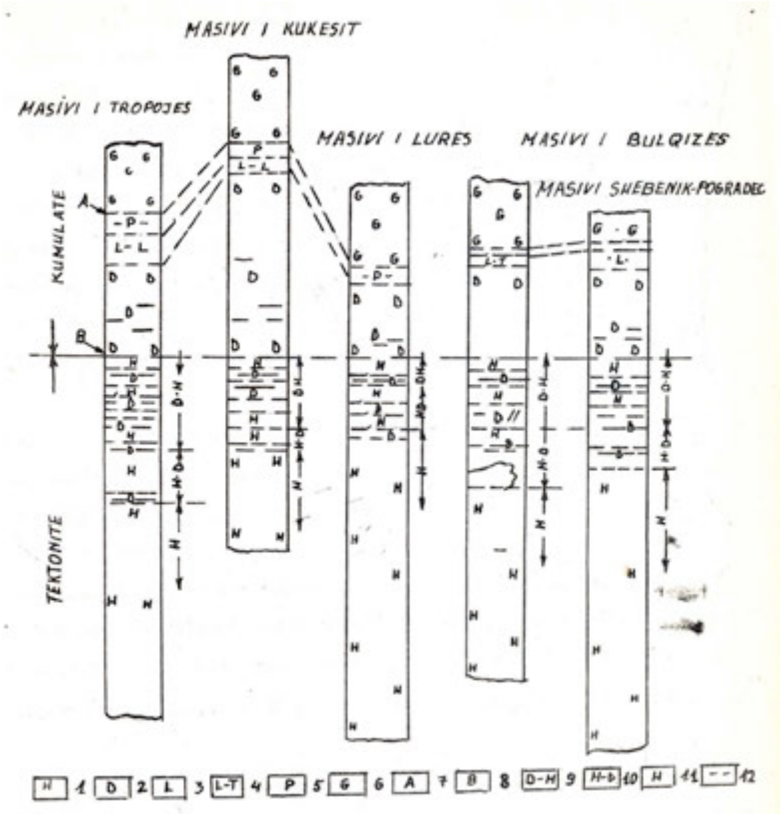

Fig. 1. The correlation scheme of the schematic geological sections of the eastern belt of ultramaphic rocks (Hallaçi H. et al, 1989).

1.Hartzburbite; 2.Dunite; 3.Lherzolite; 4.Lherzolite-troctolite; 5. Pyroxenite; 6. Gabbro; 7. MOHO velocity discontinuity; 8. MOHO petrological discontinuity; 9. Dunitic-hartzburgite facies of tectonites; 10. Harzburgite-dunitic facies of tectonites; 11. Hartzburgite facies of tectonites; 12. Mineralization levels.

The ultrabasic rocks have a magnetism, which changes in a broad band, conditioned by the presence of the ferromagnetic mineral accessories, mainly by secondary magnetite and less by the magnetized accessory chrome spinel (Tab. 1, fig. 3,4, 5). The variation of their remnant and chemical magnetism strongly depends also by the chemical transformations, recrystallization and redistribution of the mechanical stresses. Therefore, ultrabasic rocks can be classified as nonmagnetic, weakly magnetic and strongly magnetic ones. Being ferromagnetic, the ultrabasic rocks have a magnetic susceptibility, which varies also in broad limits. Apart from this, being ferromagnetic these rocks might have a large natural remnant magnetization (I_r). In this way the ultrabasic rocks can be considered from partially unmagnetic to strong magnetic.

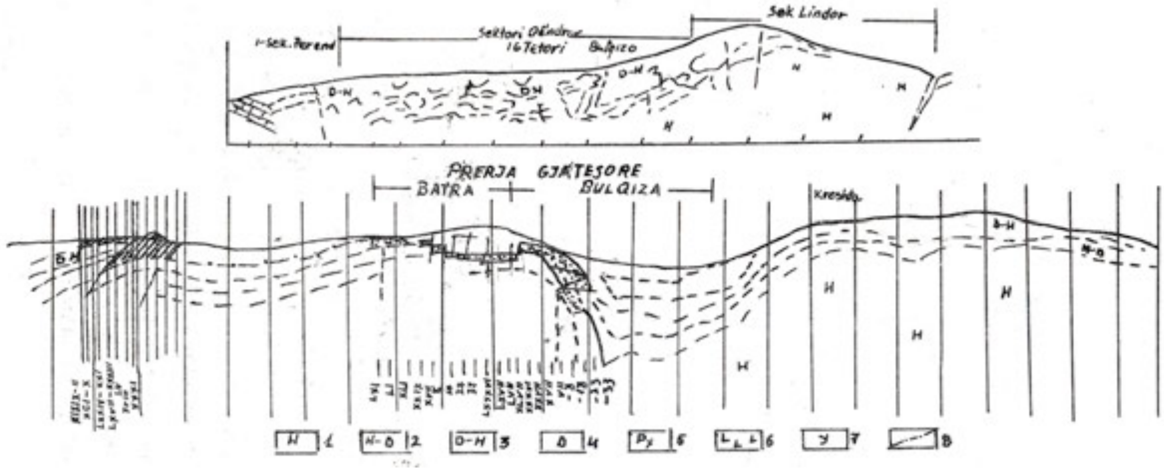

Fig. 2. Geological transversal (EW) and longitudinal (NS) sections in the Bulqiza ultramaphic massif (Hallaçi H. et al.1989).
1.Hartzburgite; 2. Hartzburgite-dunite; 3. Dunite-hartzburgite; 4. Dunite; 5. Mineralization levels.

The magnetic properties of the chrome spinel ore and the ultrabasic rocks.
(Frashëri A, 2008)

Table 1

Kind of ore or rock	Quantity of samples	Induced magnetization I_i, $*10^{-5}$ units (SI)			Remnant magnetization I_r, $*10^{-5}$ units (SI)			$Q_n=I_r/I_i$		
		Min.	Max.	Mode	Min.	Max.	Mode	Min/Max	Aver.	% of samp with $Q_n>1$
Dunite	85* 32**	0	700	10±10 50±30 200±80	10	1800	300±70	1.2/5	2.3	0.5
Serpentinized dunite	20	38	1000	350						
Harzburgite	109* 56*	0	700	15±15 300±100	20	1000	300±100	1.2/13.8	1.9	0.3
Serpentinized harzburgites	87* 14**	40	1000	300	20	1300	350±150	1.0/ 2.4	1.77	0.6
Serpentinites from dunites	82	0	3700	150±70	5	70000	300±90	1.0/ 31.0	1.8	0.6
Serpentinite from harzburgites	68	0	1100	250±50	5	9500	150±60	1.0/ 23.0	2.1	0.5
Pyroxenites	102	10	720	350±60	10	71000	150±90	1.0/ 114	4.0	0.7
Gabbro pegmatites	21	0	270	50	170	250		1.2/ 4.5	1.3	

Note: * samples quantity of I_i measurement
** Samples quantity of I_r measurement

The fresh dunites and hartzburgites of tectonic sequence are not magnetic and cannot be distinguished by their magnetization if their degree of serpentinization is equal (table 1). The magnetic properties of these two kinds of rocks vary within almost the same limits. Remnant and induced magnetization have respective values 10 x 10^{-5} units SI and 40 x 10^{-5} unit SI, so $Q_n<1$, in the fresh rocks practically unserpentinized and uncataclased. The ration $Q_n=I_r/I_i>1$ is approximately in 48% of the cases, with average value 2,3 for dunites and 1,9 for hartzburgites. That reveals the influence of the thermal nature of the remnant magnetization. With the increasing of the activity of cataclasis, magnetism is

strengthened, especially the natural remnant magnetization. The fresh rocks have unequal magnetic properties in different regions.

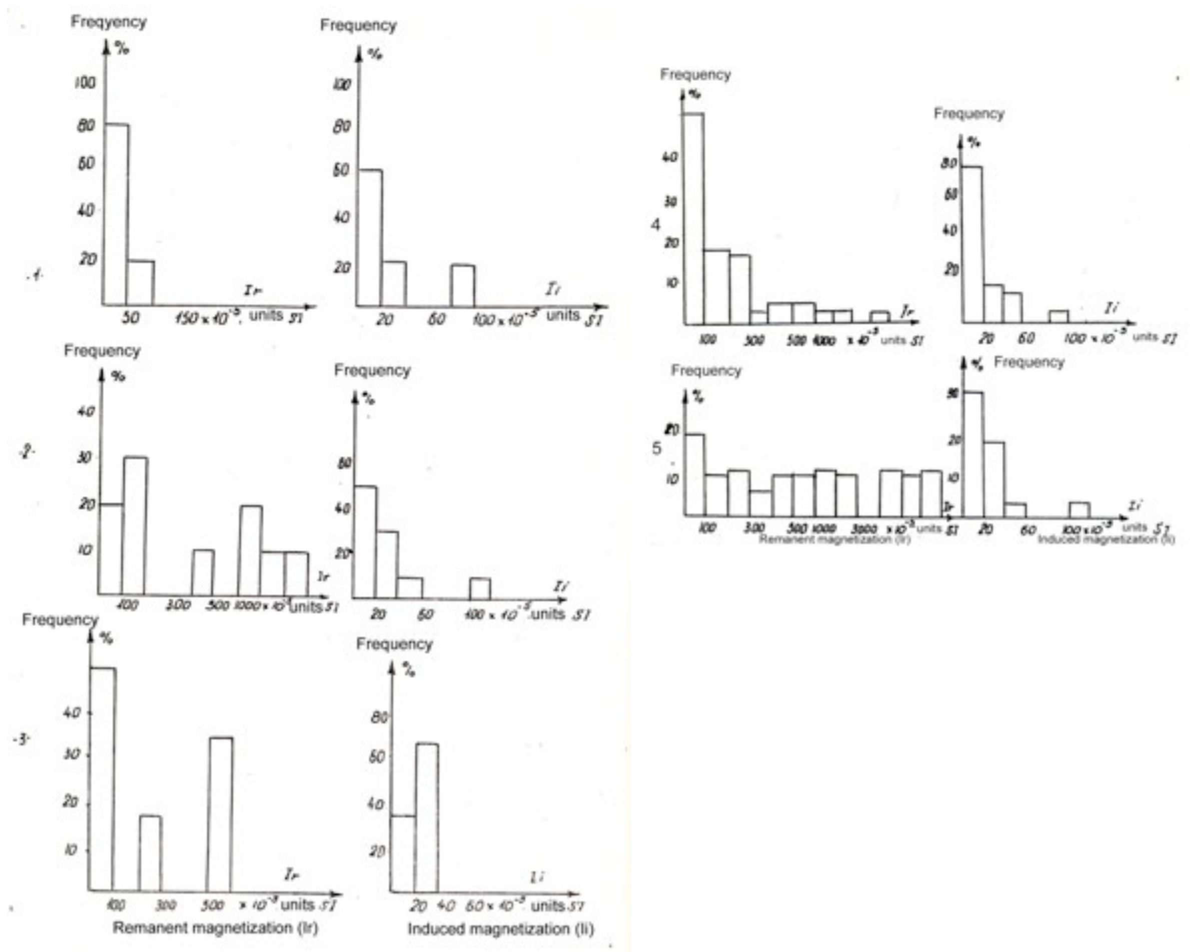

Fig.3. The histograms of the variation of remnant (I_r) and induced (I_i) magnetization of the rocks in Fushe Kalt (Bulqiza) deposit (Plotted by data Sharra Xh. Et al. 1987, accorded to the measurements of Kosho P., Dema Sh., Rrenja A.).

1. *Average serpentinized dunites; 2. Strongly serpentinized dunites; 3. Little serpentinized hartzburgites; 4. Average serpentinized hartzburgites; 5. Strongly serpentinized hartzburgites.*

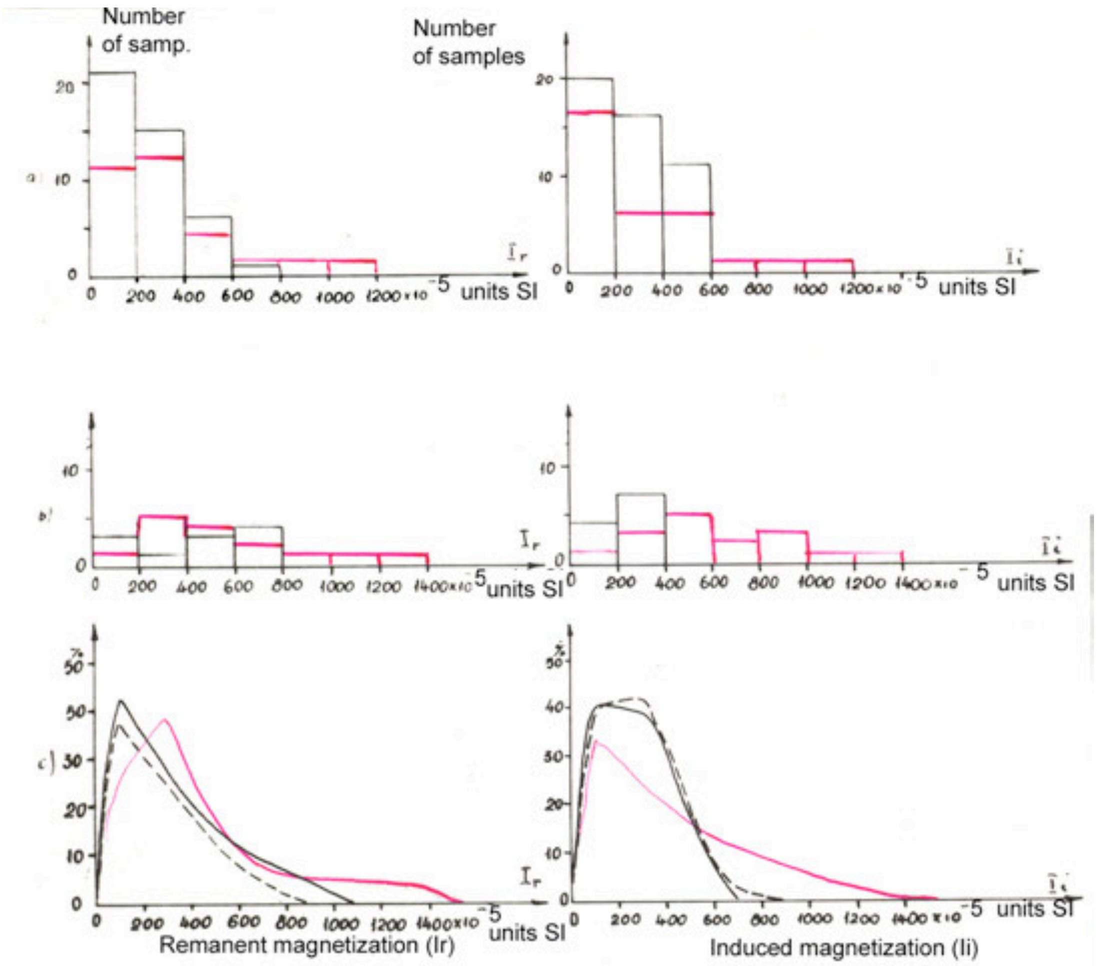

Fig. 4. The histograms of the variation of remnant (I_r) and induced (I_i) magnetization of the rocks in Kami (a), Vlahna (b) and variation curves (c) (Frashëri A., 2008).

1. *Serpentinites from dunites (55 samples);* 2. *Serpentinites from hartzburgites (59 samples);* 3. *Piroxenites (102 samples).*

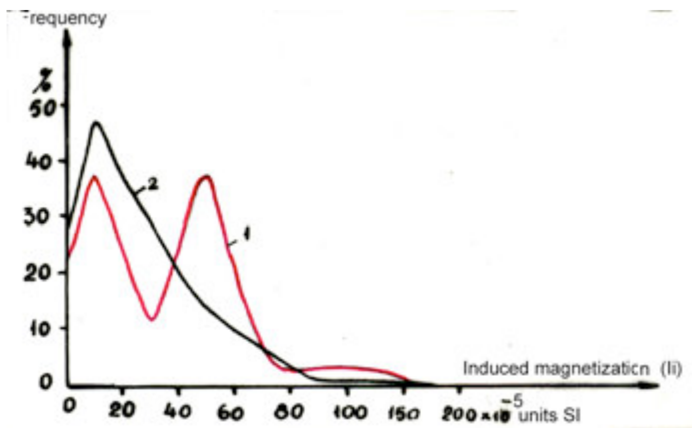

Fig. 5. The variation curves of induced (I_i) magnetization of the dunites (1) and hartzburgites (2), Ragami deposit, Tropoja Massif (Frashëri A. et al., 2008).

The rocks that contain ferromagnetic minerals, for example secondary magnetite are more magnetic. An induced magnetization (80-130) x10^{-5} units SI can be conditioned by presence of 0,1% of magnetite. In general, dunites are a bit more magnetic than hartzburgites that means that they are more serpentinized and contain more secondary magnetite. With the increase of the serpentinization process, the magnetization (in particular the remnant magnetization) of dunites and hartzburgites gets stronger. This can be explained by the increase of the secondary magnetite and the thermoremnant magnetization. The magnetism of the serpentinites has a particularly characteristic: Its values vary in a

wide range, from practically unmagnetic to strong magnetic, with values of I_r = 70,000·10^{-05} SI units and I_i = 3100·10^{-05} SI units. This phenomenon can be explained by the degree of serpentinization because the quantity of serpentines in the rocks does not always determine the quality of secondary magnetite (Photo 1, 2, 3, 4). With the increase of the serpentinization process, the magnetization (in particular the remnant magnetization) of dunites and hartzburgites gets stronger. This can be explained by the increase of the secondary magnetite and the thermoremnant magnetization. The magnetism of the serpentinites has a particularly characteristic: Its values vary in a wide range, from practically unmagnetic to strong magnetic, with values of I_r = 70,000·10^{-05} SI units and I_i = 3100·10^{-05} SI units. This phenomenon can be explained by the degree of serpentinization because the quantity of serpentines in the rocks doest not always determines the quality of secondary magnetite. For example there is met serpentinites from hartzburgites totally serpentinized and transformed into serpentine and less in carbonate, which does not contain secondary magnetite and has I_i=80x10^{-5} units SI, I_r=200x10^{-5} units SI.

Photo 1. Serpentinit from dunite, with fissures of different ages, chrysotile-asbestos and magnetite, Kam deposits. Magnetic susceptibility χ>3000x10^{-5} units SI. Thin section, enlargement 35x, Nicoles parallel. (Frashëri A.et al. 2008).

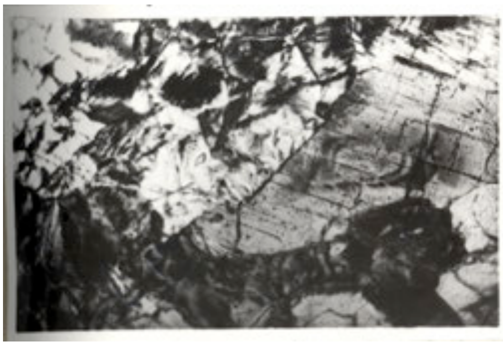

Photo 2. Serpentinized hartzburgite, with dispersed as cloud of Magnetite, Kam deposit. Magnetic susceptibility χ>3000x10^{-5} units SI. Thin section, enlargement 25x, Nicoles +. (Frashëri A. 2008).

Photo 3. Serpentinite from hartzburgite, with magnetite in the chain, cloud and grain forms, Kam deposit. Magnetic susceptibility χ>3000x10^{-5} units SI. Thin section, enlargement 25x, Nicoles +. (Frashëri A. 208).

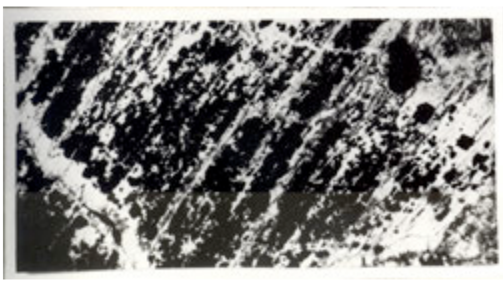

Photo 4. Serpentinite from dunite, with magnetite dense belts, Kam deposit. Magnetic susceptibility χ>3000x10^{-5} units SI. Thin section, enlargement 25x, Nicoles +. (Frashëri A. 208).

These great changes of the remnant magnetization, induced magnetization and of the Q_n ratio for chrome spinel ores, ultrabasic rocks, in general, and for the serpentinites in particular, is conditioned, not only by the contain of the secondary magnetite. These phenomena are conditioned by the chemical and mineralogical transformations of the rocks during the serpentinization and by the redistribution of mechanical stresses, as well. The effect of dislocations is observed under the action of mechanical stresses during the process of the serpentinization, of the dynamometamorphism and of the tectonic activity. For example, in Cerruja deposit, the dunites and hartzburgites of the tectonic sequence are serpentinized. The serpentine contain, in some cases, reaches from 50% up to 85-90% of the rock's volume.

Different amounts of secondary grains magnetite can be found along the skeleton network directions. Contain of the secondary magnetite in this kind of rocks is 4-5%, while contain of secondary magnetite grains inside the mass of the serpentine of the hartzburgites is 0.1-0.4%. For this reason, the susceptibility of this sequence varies in a wide range. The variation curve of the dunites has two maximums, one at the value of $120\cdot10^{-05}$ SI units and the other one at the value of $719\cdot10^{-05}$ SI units. This means that there are two kinds of dunites: weak magnetic and magnetic. The magnetism of the cumulate sequence rocks changes in the plane and in the cross-section. There are alternations of nonmagnetic and strongly magnetic rocks.

Vein rocks, like pyroxenites in the majority of the cases are made up to medium granular to coarse-grained enstatite more or less bastitized. The rock is cataclasised and in the jumping and fissures zone there is often observed contain of fine-grained secondary magnetite. The magnetism of pyroxenite varies within wide limits. However, the majority of pyroxenite are weak magnetic. The values of their induced magnetism are ($I_i = 350\cdot10^{-05}$ SI units, $I_r = 150\cdot10^{-05}$ SI units) (Table 1). With the increase of the quantity of the secondary magnetite, the magnetism increases. The ratio Q_n has an average value 4,0, but in particular samples up to 114. In these cases, the remnant magnetization has a thermal nature, under the influence of the magnetic field of the earth and surrounding rocks.

Volanic basalts and keratophyres in northern massifs in Mirdita tectonic zone have a remnant magnetization that vary o,061-3,716 A/m, although their magnetic susceptibility is higher, up to $102.500.10^{-6}$ SI units. Their magnetization is conditioned by content of ferromagnetic mineral accessories. In South-East of Albania have been observed a basalt individualization with the remnant magnetization I_r=117,803 A/m.

Gabbros magnetizations vary in different massifs. In Kurbneshi, at North-East of Albania, the gabbros have lower level of magnetization, averagely I_r=0,007 A/m and magnetic susceptibility 535.10^{-6} SI units. In Qafzezi village, South-Easter of Albania, gabbros have stronger magnetization; I_r=52,825 A/m.

Analyse of the stereographic projections of the remnant magnetization vector shows that parallel with common orientations are observed nearby samples with different orientation, positive and inverse negative. Such phenomenon argues the superposition of the isothermal and chemical and thermal magnetization on remnant thermal magnetization.

Petromagnetic studies have shown the presence of inverse magnetization phenomenon for chrome spinel ores in some deposits (fig. 6). From this picture, it can be seen that the ores in Kepenek deposit (Tropoja ultrabasic massif), are characterised by vectors of remnant magnetization oriented in the average azimuth Φ=356° and with dipping angle θ=-70°, i.e. opposite to the direction of the vector of remnant magnetization for surrounding rocks. The surrounding dunites the dipping angles of the I_r vector is averagely $\theta=60^0$, where as the azimuth $\Phi=42^0$. The sample from the dunitic envelope with I_r vector, preserving the azimuth of direction $\Phi=46^0$ (as in the rocks that are far from the ore body), has a negative inclination angle, as in ore $\theta=-11^0$. The petrographic study of the orientated thin sections show that along the direction with azimuth of about 45^0, is noticed an event more accentuated development of the action of cataclasm of the rocks, which is expressed by a great number of cracks and microfissures. The majority of the microfissures, especially the most developed, are filled with

serpentine of the chrysotile and microantigorite types and with some chrysotile-asbestos vein. There is found secondary magnetite concentrated in microfissures, especially in their periphery. Along the direction 45^0, some prolonged crystals of olivine are noticed in a lying position so the direction of the vector I_r agrees with the direction of the elements with primary structure (Photo 4.11).

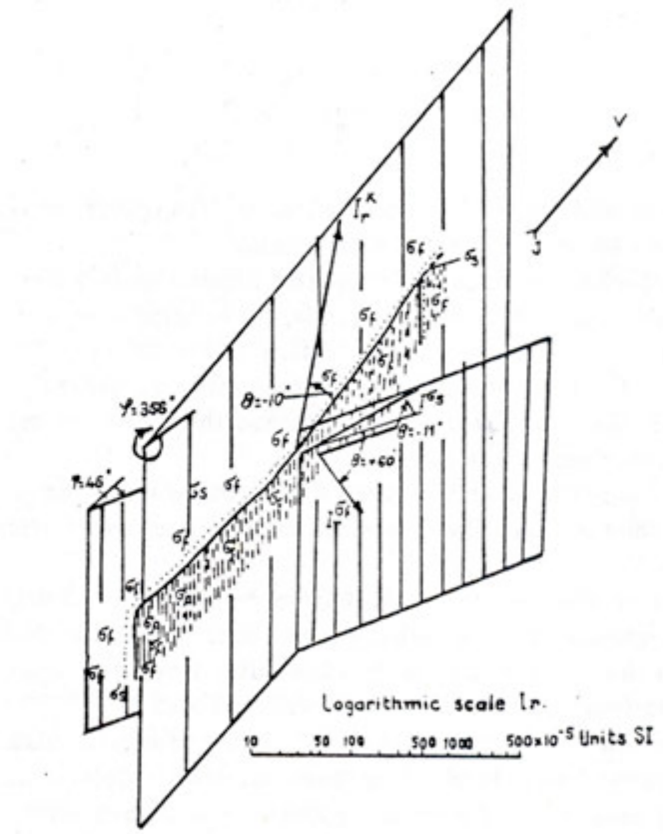

Fig. 6. The inverse remnant magnetization (I_r) for a chrome ore in Kepenek deposit, Tropoja ultrabasic massif. (Frashëri A. 1989, 2008).

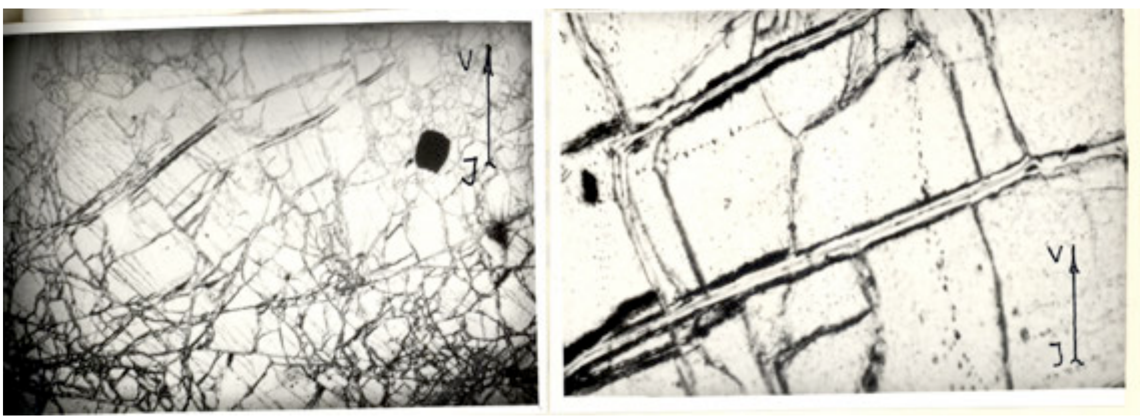

Photo 5. Direction of the cataclasis action (a), serpentine veins and secondary magnetite conentration (b) in the dunites, Kepeneku deposit. Oriented thin section. a) Enlargement 23x, Nicoles parallel; b) Enlargement 470x, Nicoles parallel. (Frashëri A., 1974).

The direction of I_r vector of the chrome-spinel coincides with the strike of the ore body. The negative direction of the inclination of the ore's remnant magnetization vector may be explained by the self inversion inside the spinel; or as a consequence of the demagnetization action of the magnetic field of the surrounding rocks (when the ore body was created after the process of the crystallization of surrounding rocks). These rocks were already magnetized and the ore was magnetized under the

action of the demagnetising field of the surrounding rocks (Fig. 7). Under the thermical influence of the ore matter, in the dunitic envelope of the ore body the direction of the I_r inclination has changed.

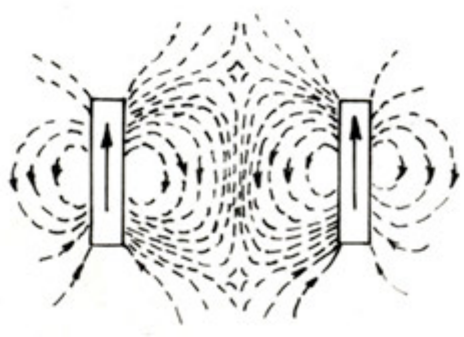

Fig. 7. Distribution of magnetic lines in the space between two bodies near each other, with the magnetization vectors in the same direction and sense.

There are some geological facts that are in the favour of this idea: Among the ultrabasic rocks there is also met chrome spinel ore, with a surface surrounded by 2-3 mm dunite salbande, yellow colour unlike the for dunites, which are more or less green (Photo 4-12). The microscopic study of the polished section has shown that chromite intercalates in the olivine and the part near of the contact is more serpentinized than the other part. This phenomenon shows the thermal influence of chrome spinel on the surrounding olivine. Apart this phenomenon there is also met ore that has cemented regular pieces of olivine (Photo 4-13). The mineralographic study showed that the order of the formation of the minerals is olivine-chrome spinel ore. Olivine has been recrystalized before the chrome spinel ore. There are also noticed intercalations of the chrome spinel veilets in small dimensions in the olivine mass. Many other scholars have reached also the same conclusion on the relative later formation of chromite spinel ore and have proved this thesis in many publications (Çina A. et al. 1966, Çina A. 1970, Dede S. 1965).

Photo 6. Surrounding yellow olivine salbande on chrome spinel ore, Kepenek deposit. (Frashëri A. 1974).

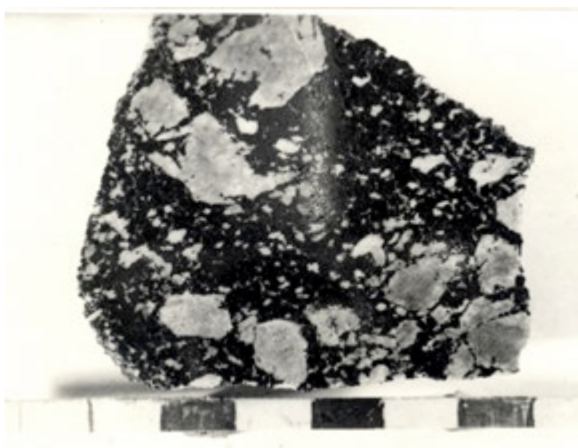

Photo 7. Chrome spinel ore has cemented irregular olivine pieces, Kepeneku deposit. (Frashëri A. 2008).

The reversal of the remnant magnetization vector has been also noticed in some other deposits, such as in Kam (Tropoja), Fushe-Kalt (Bulqia) etc.

In cumulate sequence and the surrounding dunite and hartzburgite rocks (for example in Cerruja deposit, Bulqize) have observed a normal vector of remnant magnetization. This vector has a downward direction and a dip angle of 40°. This shows that the ore bodies have been created at the same time with the cumulate sequence rocks.

Although these differences of the ophiolite magnetization, for some massifs is preserved approximate orientation of the vectors of remnant magnetization (Fig. 8). Predominant orientation of remnant magnetization vector have and azimuth $D=284^{o}$ for pillow lava and $D=297^{o}$ for volcanic basalts in central part of Mirdita zone. Azimuth $D=267^{o}$ of the magnetization vector have gabbro of Kurbneshi massif in this part of Mirdita zone.

In contrary with volcanic rocks and gabbros of central part of Mirdita zone, fig 4 are presented dependance the hartzburgites are represented by a dispersion of the azimuth of magnetization vectors in large limits in Bulqiza ultrabasic massif, $D=60^{o} – 300^{o}$, as well as preserve the positive sense of the vectors. This great variation of the direction of azimuth of magnetization vectors is conditioned by serpentinization process of he ultrabasic rocks, iven or low lewel of the serpentinization.

In the North-Erstern edge of the ophiolitic belt of Albanides, in he Komani site, the volcanic rocks have e clockwise rotation, analogue with External Albanides (Fig. 8).

Have been received interesting result from the thermal cleaning and demagnetization in the magnetic field of the alternative electrical currents of the sample from the gabbros massif in Qafzezi, South-Easter region of Albania (Fig. 8). The orientation of the magnetization of gabbros in Qafzez Massif in South-East of Albania, has an useful magnetic signal after cleaning and demagnization, has a vector with $I_2=60.9^{o}$ and azimuth $D_2=282^{o}$. This direction is approximate with orientation of the magnetism vector of the gabbros massif in Chalkidiki, Greece, $D_2=312^{o}$ and $I=68^{O}$. The ophiolitic belt of the Chalkidiki was undergone two tectonic phases: first a counterclockwice rotation during Later Jurassic-Lower Cretaous and the second one a clockwise rotation during Terciary (Edel J.B. et al., 1991).

4. Conclusions

Based on petrophysical properties of the ultramaphic rocks and chrome ores it was concluded:

1. The physical properties of the ultramaphic rocks vary within broad limits and only in some cases a group of rocks can be differentiated by its physical properties from the surrounding rocks. The cumulate and the tectonic sequences are discriminated. These groups of rocks can create geophysical anomalies comparable with the ore body anomalies.
2. Fresh rocks are not magnetic. The magnetism of serpentinites changes within wide limits. They are usually magnetic and sometimes strongly magnetic. Non-magnetic serpentinites can also be found. The dunites of cumulate sequence are more magnetic than the other rocks.
3. The ultramaphic rocks can be distinguished from the surrounding rocks and from each other by their magnetism only if they have different degrees of serpentinization.
4. In some deposits and occurrences is observed inversed vector of magnetization. In these cases, the negative magnetic anomalies can observe over the magnetic chrome spinel ores.
5. The study of the orientation of the remnant magnetization vector of the ores and the surrounding rocks can be used as a supplementary information source about their formation conditions and consecutive changes in time.

6. Acknowledgments

We express our thanks addressed to Prof. Dr. Condopoulou Despine, Geological School, Aristotle University of Thessaloniki, and to Pruner Peter, Magnetic Laboratory of Institute of Geophysics,

Academy of Science, Prague, for the help they gave us for paleomagnetice definitions of the ophiolitic rocks to their labs.

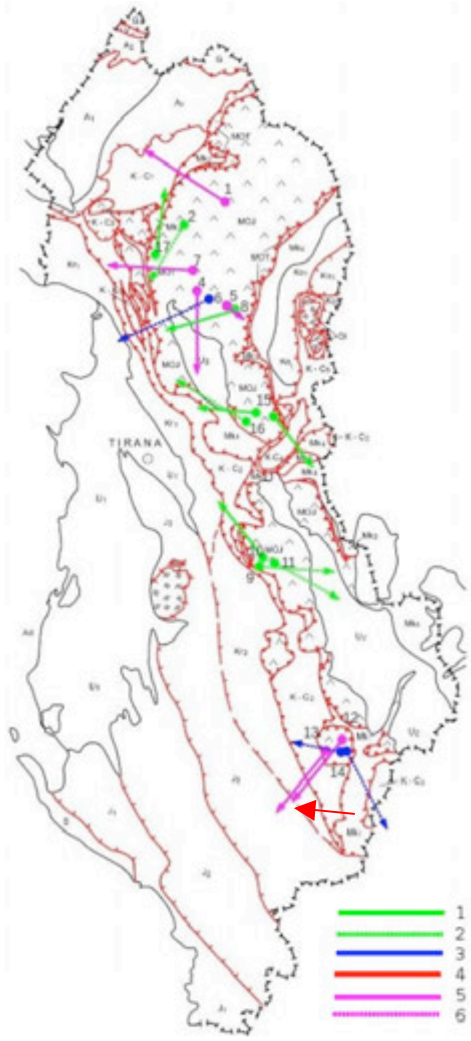

Fig. 8. Declination of the magnetization vectors of the ophiolite belt in Mirdita tectonic zone of the Albanides.

Tectonic zones:
Internal Albanides:
M- Mirdita zone
G- Gashi zone
Ko- Korabi zone

External Albanides:
A- Albanian Alps
K-C- Krasta-Cukali zone
Kr- Kruja zone
J- Ionian zone
S-Sazani zone
U- PeriAdriatic Depression

Magnetic declinations:
1- J > 0 Ultrabasic rocks
2- J < 0 Ultrabasic rocks
3- J < 0 Gabbro
4- J > 0 Gabbro, remnant magnetization after demagnetization
5- J > 0 Volcanic rocks
6- J < 0 Volcanic rocks

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THE SYSTEM "PRESPA LAKES – OHRID LAKE": THE ACTUAL STATE - PROBLEMS AND PERSPECTIVE

A REVIEW ON ANTHROPOGENIC IMPACT TO THE MICRO PRESPA LAKE LIMNOLOGY

Niko PANO

Alfred FRASHERI

Struga – Pogradec , 27 – 29 October 2013

INTRODUCTION

The paper presents the environmental problems of Prespa Lake system, which is the pearl of Western Balkan region.
This system is composed of Micro and Macro Prespa Lakes, and present an important limnological object.

Prespa’s hydrographic network is located in the three-state border area: between Albania, Macedonia and Greece, which have the common interest for maintaining and recuperating the special natural hydro-ecological values of European dimensions in this area.

GENERAL AREA DATA

The study area it is part of three Lakes System:
-Micro Prespa (1),
-Macro Prespa (2), and
-Ohrid (3).

These lakes are located a t the foot of the rocky Dry Mountain,Galicica Mountain in Macedonian territory, which has a maximal altitude of 2287 m.

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This system has
a catchment area of
1 363 km2. It is
located on 850 m.
above the sea level.

Macro Prespa has
a maximal depth 55 m
And surface 276 km2.

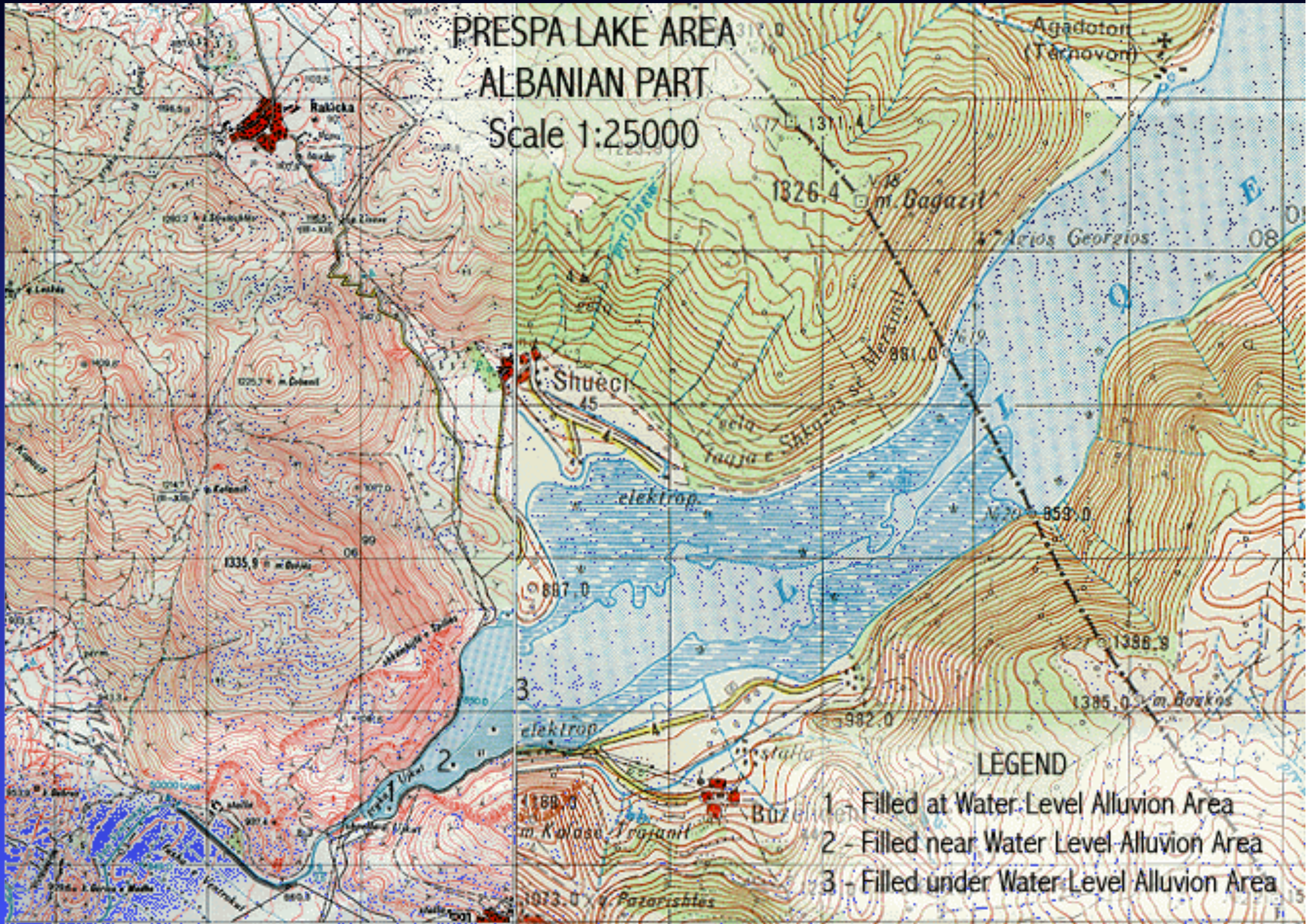
MICRO PRESPA
Lake

Micro Prespa is a two-national lake, lying in the territories of Albania (12.1%) and Greece (87.9%).

Micro Prespa has a surface 43 km2
I ts maximal depth is 8 m.

Micro Prespa Lake

Albanian side of Micro Prespa lake



Prespa Lakes have great and special ecological values:

- picturesque nature,
- particular climate,
- rich biodiversity,
- extremely complicated karstic hydrography,
- high transparency of dark blue
- waters and uncommonly diversified, beautiful coastline.
- very rich biodiversity.

Prespa Lakes has a very important influence in the general water balance of the Ohrid Lake.

-

Beautiful Micro Prespa Lake and surounding area

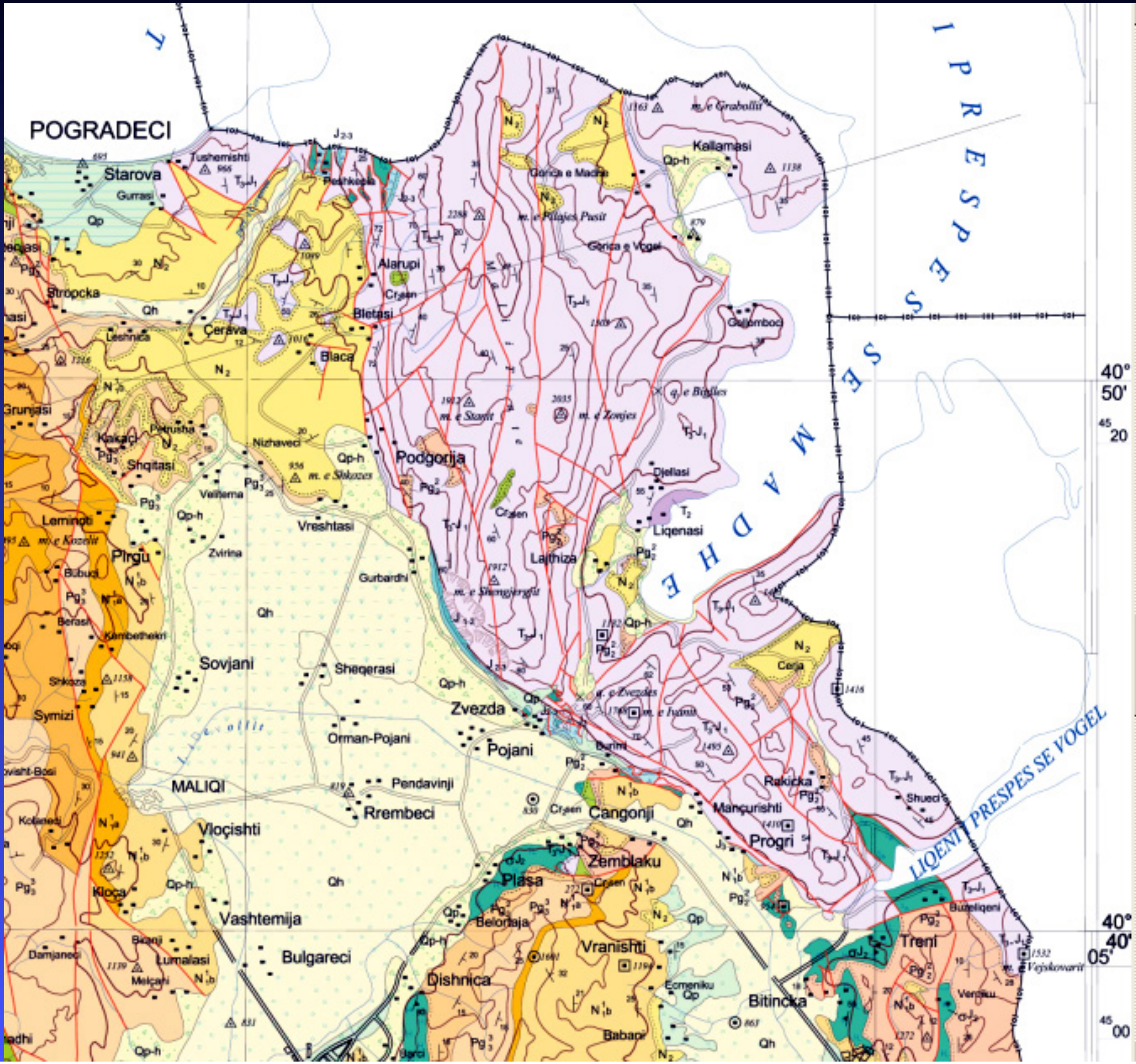
INTEGRATED STUDY METHODOLOGY

Environmental impact and ecosystem destructions of Micro Prespa Lake have been studying by a multidisciplinary complex methods:

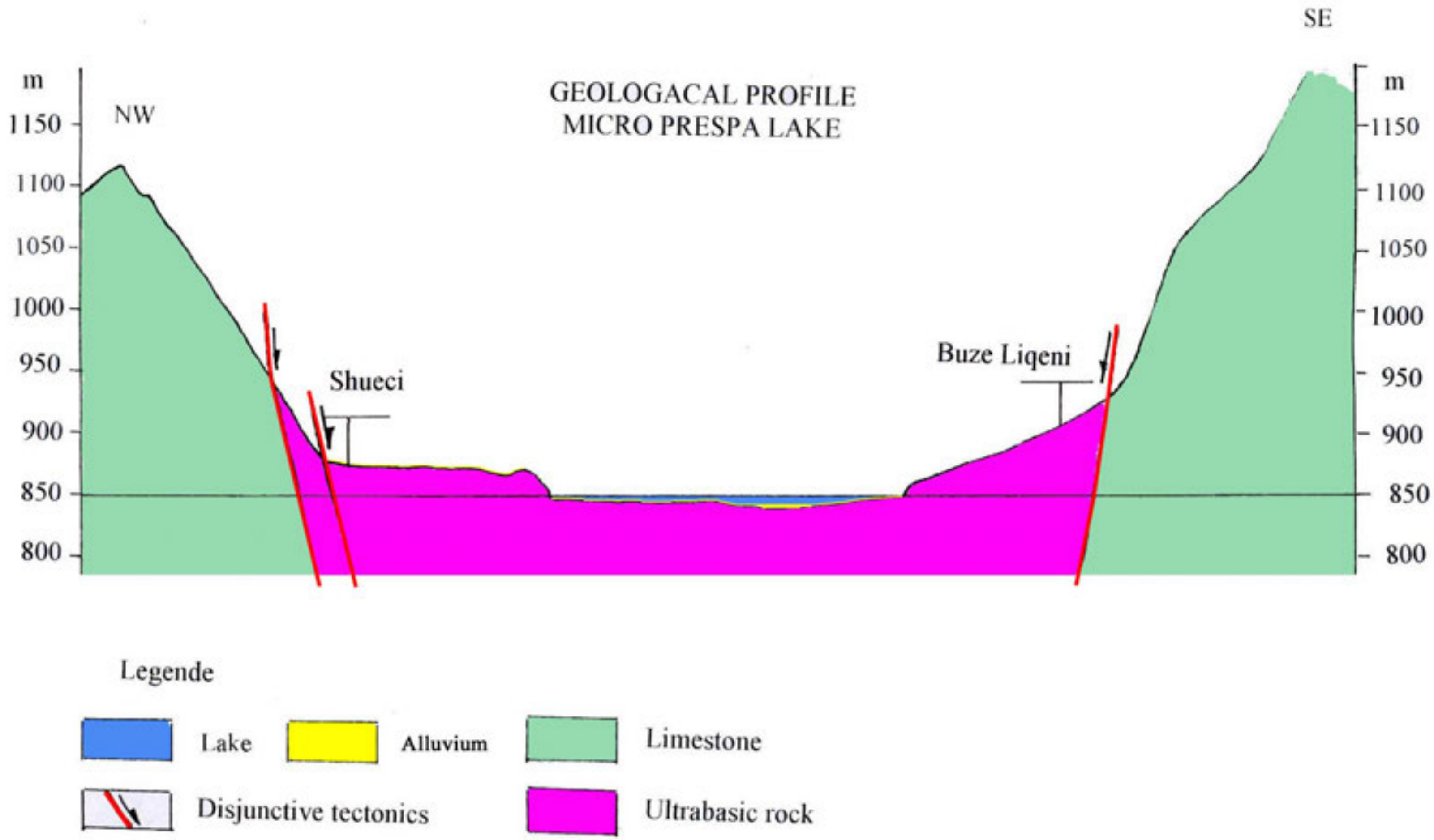
- remote sensing analysis,
- hydrographical and limniological studies,
- hydrogeological, geological, and in particular neotectonics surveys,
- biological, and environmental investigations.
- *Special attention was being paid for the analysis of the uncontrolled human activity in Prespa ecosystems.*

- Particular attention was given to estimation of the:
- multi annual hydrological parameters of lakes and atmospheric conditions,
- solid sediment transport from Devolli river at Micro Prespa Lake,
- chemical contamination of river and lake water by chemicals used in agriculture.
- the investigation of karstic phenomenon and
- circulation of groundwater through karstic space.

REVIEW ON AREA GEOLOGY



Tectonic's origine of Micro Prespa Lake



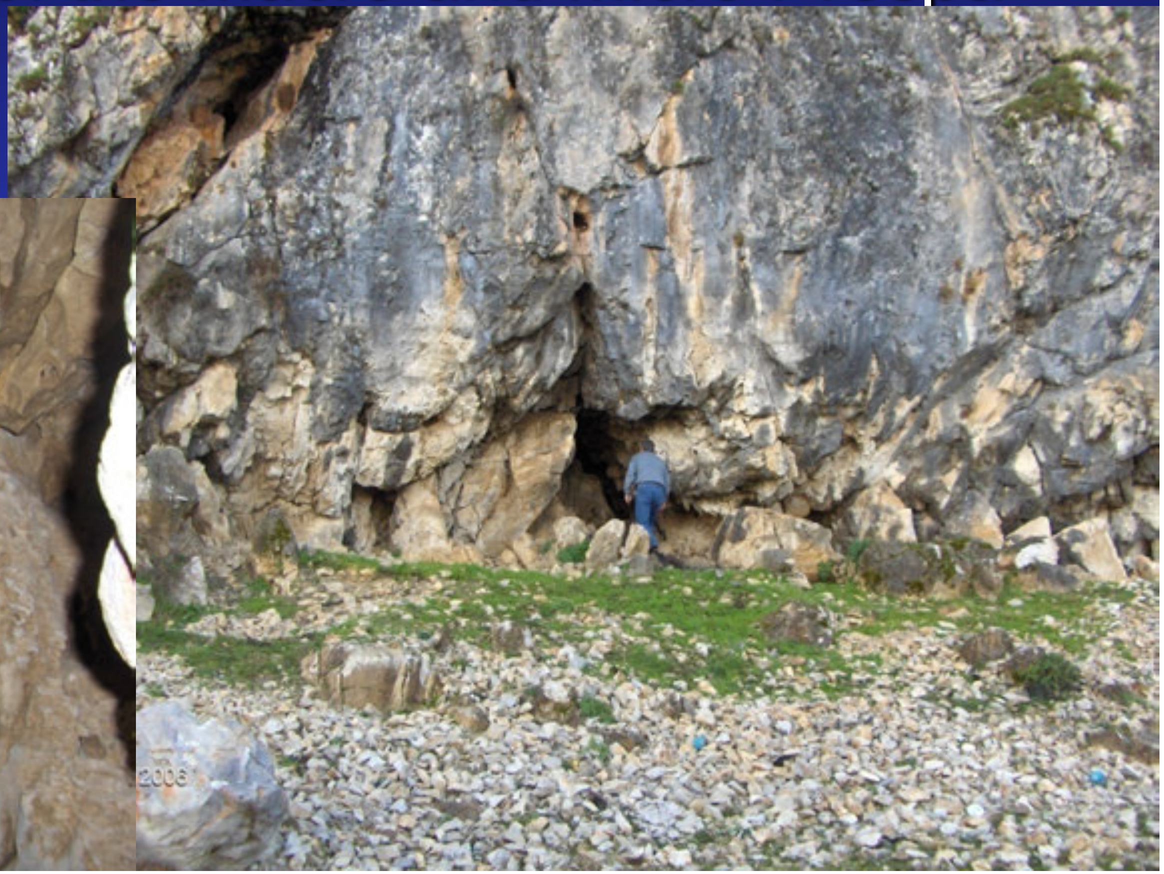
- Prespa Lakes are located in the piedmont of a horst of the carbonate structure (T3-J1) of Dry Mountain, which are intensively tectonized.

- In the northwest of Macro Prespa Lake Pliocene clay and sandstone deposits are settled. Placers deposits, clay, argillite, clayed sand, sand, gravel, cobbles, broken stone of recent Quaternary are located over the Pliocene clay-sandstone and Eocene flysh lakeshores.

- Ultrabasic rock individualization interrupts the Albanian side of Micro Prespa Lake. Ultrabasic rocks have a tectonic contact with limestone.

- The Pliocene terrigene continental deposit shown that was deposited in the inter-mountain lakes and in the deltas of the rivers, which was flowed in these lakes. This fact demonstrated that under the neotectonics development, following contrast relations of the uplifts and plunges has been created the depression where are sediments the deposits .
- These lakes started to form during the Pliocene about 5.5 million years ago and were completely formed in Holocen period.

- Limestone landscape is typically karstic, rugged microrelief, karstic channels, fosses, and caves. Karstic activity was developed at the same time . So both, tectonic and karst development have been created the conditions in formation of the Macro and Micro Prespa lakes.

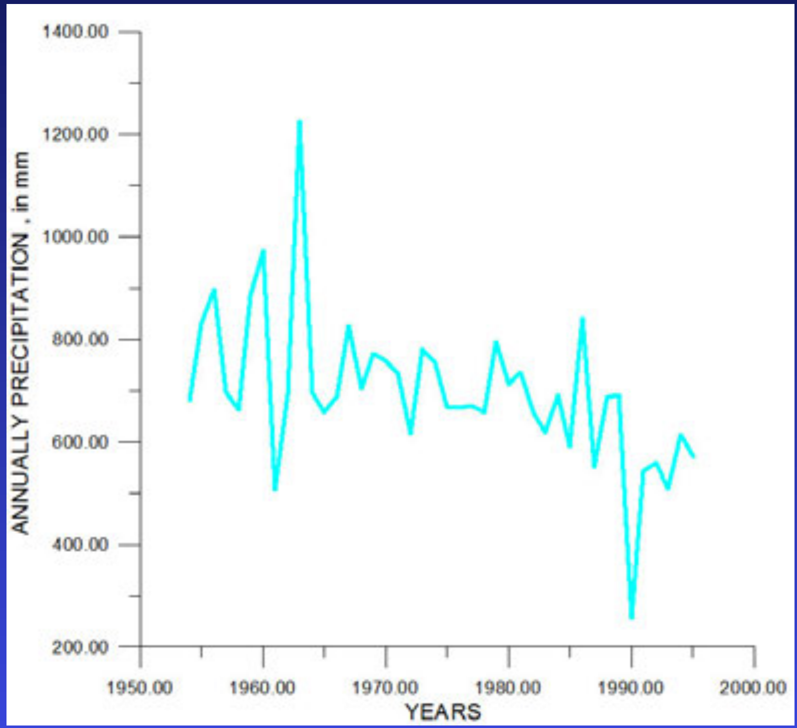


Karstified limestone of the ceiling of the Treni Cave

- Area geological settings is the main factor that conditioned lakeshore stability of the Prespa lakes. High and abrupt lakeshores are located at limestone’s sectors .
- Relatively un-stable are lakeshores in the Quaternary, Pliocene clay-sand’s deposits or Eocene flysch sectors.
- There was intensive
- erosion in all Prespa
- area rocks so a great
- quantity of alluvial
- sediments is carried
- and deposited to
- the bottom of these lakes.

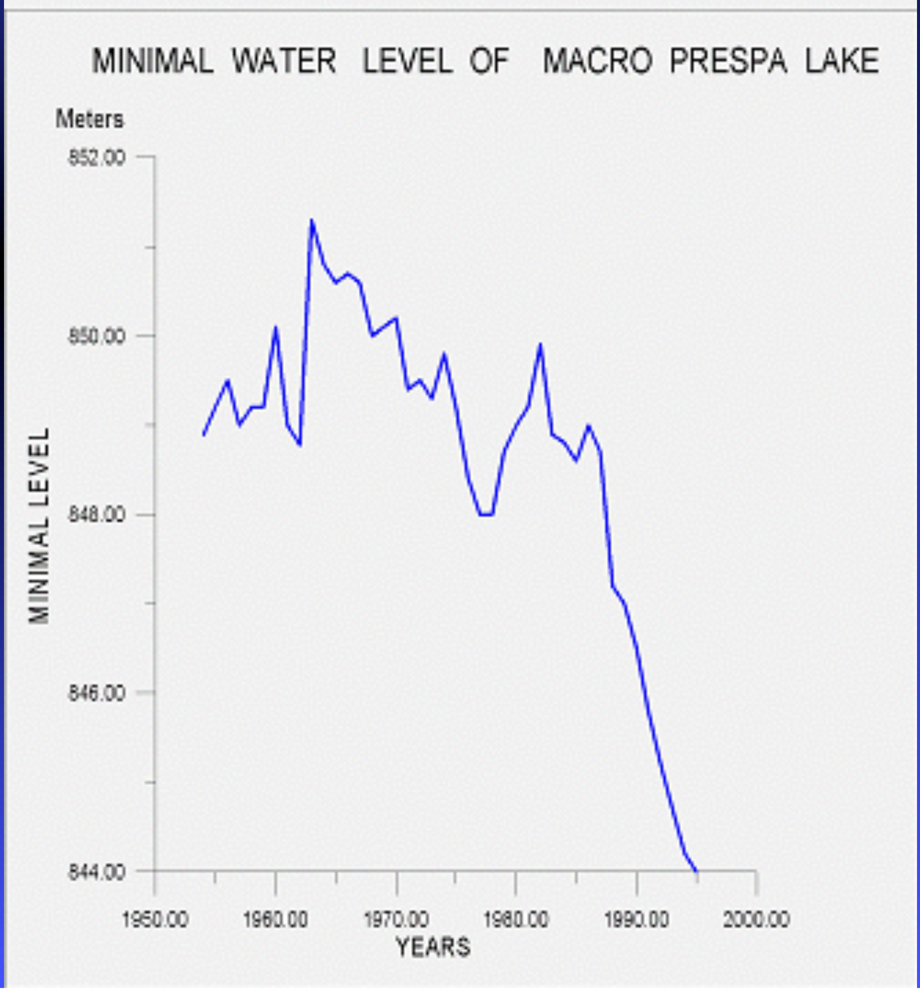
UNDERGROUND WATERS RESOURCES

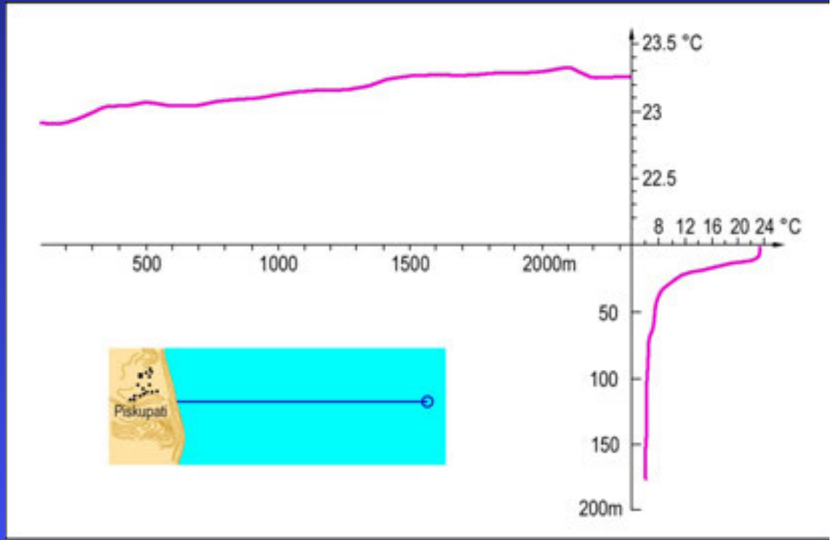
- Prespa district is rich in subterranean water resources which are linked with the existence of the two Prespa lakes, masive karstified limestone of Dry Mountain and the precipitation water infiltration in to karstified limestone.
- In the western slope of
- Dry Mountain there is a series
- of karstic springs. Their yield
- are determined by very
- developed underground
- karstic connections and water
- circulation with a big yield,



The springs which emerge in the Saint Naum lakeshore, in the Ohrid City in Macedonia, and in Drilon, Tushemisht etc. in Albanian territory, or those at the bottom of the Ohrid Lake, have a general yield of 12-15 m3/sek.

- But, alluvium which have sedimented in Micro Prespa lake floor has closed the underground water flow connections of some springs that are situated under the lake level.





- According to the isotopic hydrogeological studies it results that it is the same content of the 18O isotope of the oxygen and deuterium in the Ohrid and Prespa Lakes, and Tushemishti and Saint Naum springs). *It is assumed that all Ohrid Lake springs have a initiate from the Macro Prespa Lake, through the subterranean connected ways, which has a higher water level about 151 m.*

Biodiversity and present legal protection status

- The Prespa area envrironment is aride. The Flora – vegetation and forests with 71 sorts of trees, shrubbu trees, and the aquatic bed plants extend in some sectors:
- The aquatic bed plants: Caratophyllum sp., Myriophyllum sp., Lemna Minor, Nymphaea Alban, etc.
- The trees: Salix sp, Querqus Cerris, Querqus Pubescens, Querqus Petrea, Fagus Silvatica, Oatria Caprinifolia, Fraxinus Ornus, Carpinus Betulus, Acer Pseudoplantanus, Pinus Nigra, Abies, etc.
- The Emergents:Carex sp., Trifolium sp., Phragmites australis, Tupha sp., Scirpus sp., etc.

- The fauna of the Prespa Lakes distinguished by:
- ***Rare fish*** Rutilus prespensis,Chordrostoma prespensis, etc.
- ***Birds***: Pelecanus criptus Bruch (Photo 6 a,b), Pelecanus onoctotalus, Pholacrocorax etc.
- ***Mammals*** are habitants of the Prespa area, as Rhinolophus ferrumequinum, Pipistrellus nathussi, Glis glis, Canis lupus, etc.
- ***The Polygonetum amphibii*** are very sparseness associacion in the Prespa lakes.
- ***The pelagic zooplankton*** community of Microprespa Lake consists of 43 species. The main representatives of the zooplankton are composed by: Protozoa-1 specie, etc.

The biodiversity of Prespa and the surrounding area is very rich

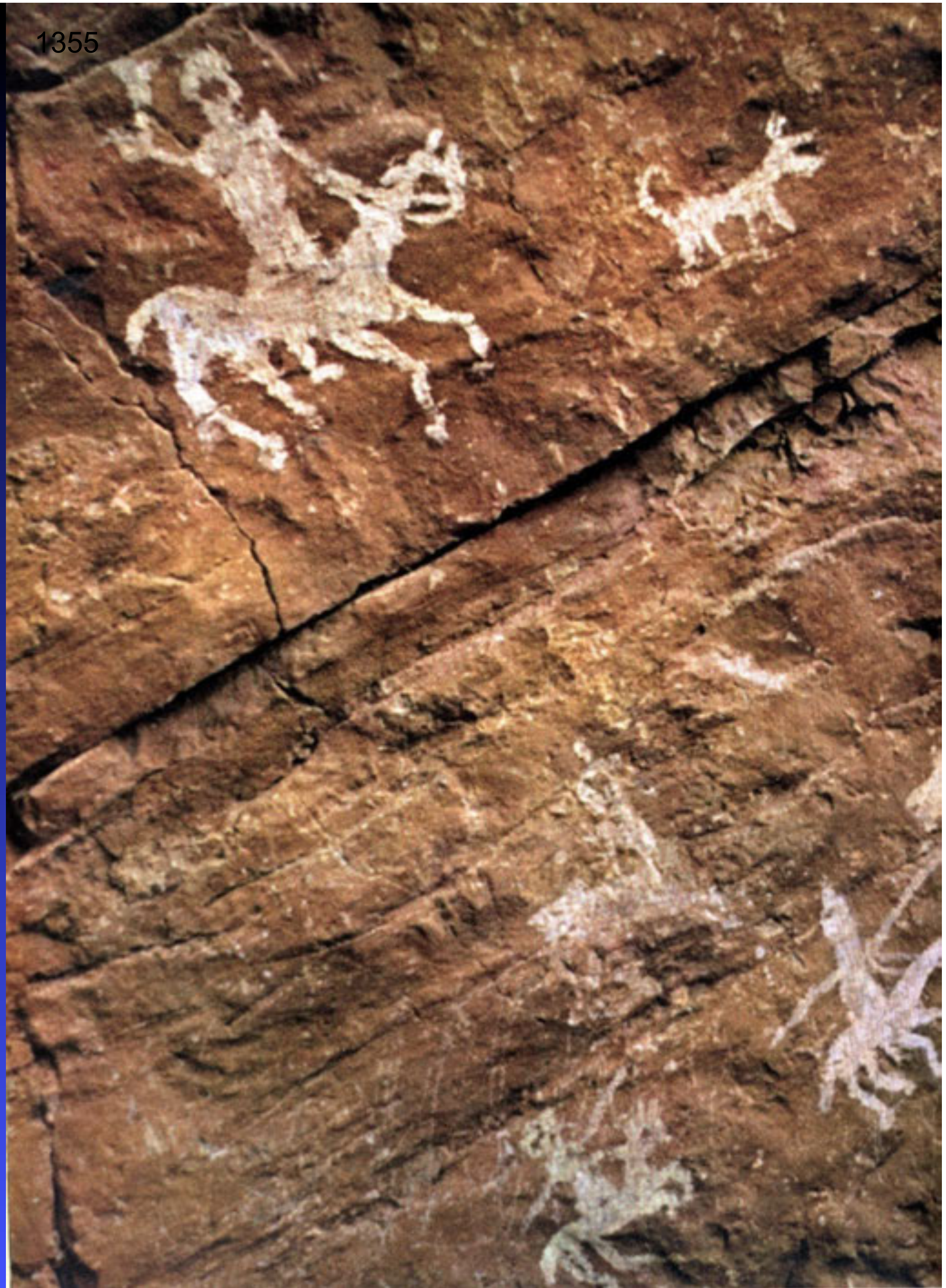
The Pelican

Prespa Zone has great historical values: has been inhabited since prehistoric times.

TRENI Prehistoric Cave ,.

in the southwestern lakeshore of Micro Prespa

The prehistoric paintings in the coastal limestone cliffs of Micro Prespa Lake



Monastic sanctuary

ANTHROPOGENOUS IMPACT

Unfortunately, anthropogenous activity has greatly damaged the ecological values of Prespa Lakes system for a long time (Pano, N. and Frashëri, A: 2000):

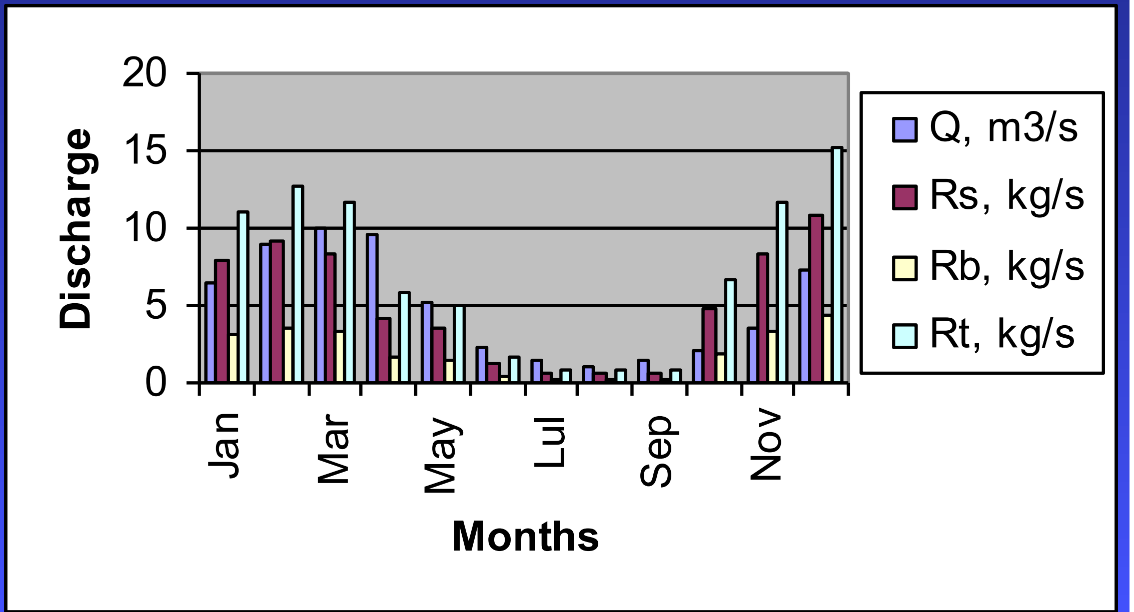
The construction of the hydrotechnical works:

- Supply of Micro Prespa lake with Devolli River water Network channel (1976), for the irrigation of the plants,
- Opening of new agricultural land against agrotechnical criteria,
- Discharge of polluted urban
- and industrial water into
- this system etc.

Mlonthly distribution of hydrological parametrs of the Devolli River

Devolli River, which is one of very turbid rivers:
-Waters of Devolli River have a mean mineralization M = 483 mg/l
- Granules with a diameter less than 0.02 mm have predominated in this sediment.
-Granules with a diameter less than 0.002 mm are up to 14% of this sediment mass.
-Great amount of Devolli River waters flowing in to Micro Prespa Lake during the winter.

A considerable amount of solid matter enter in to the Prespa Lake and were decented in the lake.



The influence of the hydrotechnical constructions on destruction and ecological stress of the Micro Prespa Lake.

- The channel, costructed in 1976 has a water capacity Q=10 m3/sec to supply Micro Prespa Lake with Devolli River water during the winter
- 30-70 million cubic meters water a year was discharged into Micro Prespa Lake through this channel.
- The maximal water hyplometric level in the lake was 852.2 m at end of the supply period.
- During the summer, the lake water has been used for the irigation of Korça and Devilli plains, with a surface of
  22 500 ha.

The maximal quote of exploitation, by the project has been 850.2 m.and can be used 90 milion cubic meters of water.

- To avoid alluvium a decanter, have been constructed, which in reality doesn't work. Studies have shown that Devolli River water flows undecanted into Micro Prespa Lake, depositing about 1.2 million cubic metters of alluvium, which has resulted in lowering of the water volume, lake surface and drastically damaging the lake ecological values. Being free of alluvium, but not by the chemicals, the water flows into Macro Prespa lake, converting into international waters.

..

In these condition Devolli River-Micro Prespa Lake irrigation system ist' n scientifically based not only on environmental engineering but also but also on hydroeconomial and international rights laws.

Water quantities taken from Micro Prespa in summer, especially during the last years, have been les that 10% of the volume of the water inserted into the lake. So for ex., in 1997, only 2.3 million cubic meters was taken away instead of 90 million cubic meters projected to be taken. This happened because Micro Prespa Lake communicate with Macro Prespa Lake through a channel in Grrece.

Turbid water of Devolli River upon flowing in Micro Prespa Lake decant in it, ruining it and, being free of alluvium, flow in Macro Prespa

Albanian side of Micro Prespa Lake is filled with alluvium 2000 y.

2006

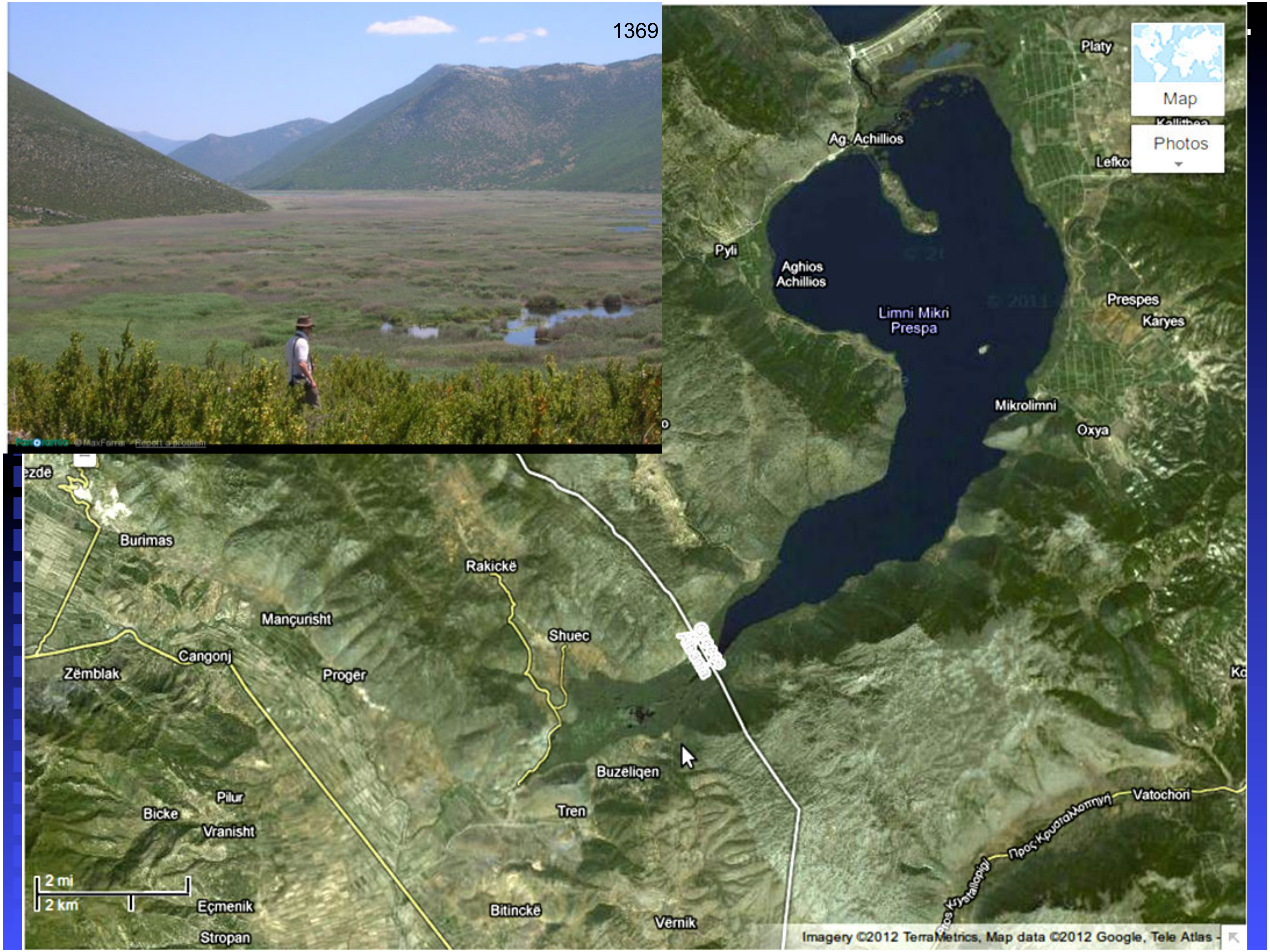

19/11/2006

PAMJE E PERGJITHESHME E DEMITMIT TE EKOSISTEMIT NE PRESPEN E VOGEL

2000

2006

2006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Eçmenik
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Προς Κρυσταλλοπηγή
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Imagery ©2012 TerraMetrics, Map data ©2012 Google, Tele Atlas

Underground water resources and springs

- Lacustrine alluvium has coated all shallows of Micro Prespa lakeside and has blocked its underground water ways. As a result water balance of Micro Prespa Lake is ruined and drinkable water springs yield is diminished. There are springs such as Ventrok that had a great discharge of 13.8 l/sec before the lake was stuffed with sediment deposition that is drying up.

Damages of the biodiversity

- Micro Prespa Lake has great problems of eutrophism . Eutrophication processes are promoted by enrichment in nutrients. The direct consequence of such addition is represented by a change in biodiversity.
- Another negative aspect is the penetrating of a considerable quantity of toxic remains and absorbed coal organic material by the drainage of Devolli farm grounds and by geological section outcrop.

The lake water content nitrite, nitrate, ammoniac, phosphate, carbonate, and organic material. Chemical change of the water has been observed up to a distance of some hundred meters, from the southwester edge of lakeshore to inside of the lake. This changes the lake water features and degrades their habitats.

Habitat loss and deterioration of over the last five years are the major factors causing serious threat to plants and animal species.

OTHERWISE OF ALBANIAN TERRITORY IN THE PRESPA AREA – AS A CONCLUSION

- The uncontrolled human activity have helped sediment deposition of about 1.2· million cubic meters into Minor Prespa Lake, diminishing the water volume and the surface of this lake. Albania has not any part in Micro Prespa Lake in this pearl oof nature. It is the otherwise of the Albanian territory, violating constitution of Republic of Albania.

- This destruction of the Albanian side of Micro Prespa Lake has an influence on all water volume of this transborder lake, with international status, as Ramsar Convection, International Park and Special Protection Area-79/409/EEC.

…

- Being scientists, we made an appeal to local community and government, state government and scientists of different fields to take urgent measures to regenerating Albanian Micro Prespa area, improving the life of the local inhabitants and transforming the district into a wonderful tourist place.

Thank you for your attention!

72 Impact of the Climate Change on Adriatic Sea Hydrology

Pano Niko, Frashęri Alfred, Avdyli Bardhyl and Hoxhaj Fatos

Abstract

In the paper there are presented the impact of the climate change on Adriatic Sea hydrology. The study is based on the results of inversion of 6 thermologs data for the ground surface temperature history in Albania, and climate change according to the meteorological data from different regions of Albania. The wells and the meteorological stations are located at the field region in the west of Central Albania and in the mountainous region of the northeast Albania. Ground Surface Temperature history presents a gradual cooling before a middle of the nineteenth century, followed by 0.6 K warming. This warming mainly after the second half of the twentieth century is presented also by meteorological data. The warming has caused its impact on country climate, inland and coastal water systems and ecosystems of the Albania, and to the Adriatic Sea hydrology.

Keywords

Ground temperature • Climate changes • Hydrology • Hydrographic system • Adriatic sea • Environmental impact

72.1 Introduction

Water discharge from the Albanian Hydrographic System into Adriatic Sea is one of the main factors, which determined processes of the forming and circulation of the Adriatic Sea water mass. Analyze of the factors that conditioned water discharge and their impact on Adriatic Sea Hydrology are presented in the paper.

In the first part of the paper is presented detailed analyzes of the climate in Albania, the ground surface history (GSH) and paleoclimate change according to the temperature measurements in the different wells in Albania. Climate changes during the last half of the twentieth century has been analyzed also based on the meteorological data. In paper is estimated continental water flow, created by atmospheric rainfalls and its impact on processes of the forming and circulation of the Adriatic Sea water mass has been analyzed.

According to the complicated nature of the Albanian Hydrographic System, in the second part of the paper, is presented the analytical methodic for estimation of the total continental water flow in this system.

72.2 Materials and Methods

Climate change are analyzed in two directions: firstly by temperature record in the deep wells and shallow boreholes, and secondly by the meteorological observations data. The

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ground surface temperature reconstruction for long period, about 5 centuries, has been performed by estimation of the ground surface temperature changes at the past, according to the present-day distribution of the temperature at the depth, recorded in the borehole (Frashęri 1995; Frashęri and Pano 2002; Frashęri et al. 2008). Six thermoplots were used for inversion of the ground surface temperature history. Wellsare located at the plane region in the west of Central Albania, and in the mountainous region of the northeast of the Albania.

Air and ground temperatures, total annual rainfall quantity, wind speed and wetness, which are analyzed by records in Meteorological Stations. These stations are located in different plane regions (Shkodra, Tirana, Kugova and Fier) and in mountainous region of Albania (Kukes), where the investigated wells are situated (Albanian Climate 1978; Boriçi and Demiraj 1990; Gjoka 1990; Mici et al. 1975, the data for 1985–2000 after Mustaqi V).

Water potential of the Albanian Rivers System have been evaluated by a specific way, because this System is very complicated (Pano 1974, 1984, 2008). Albanian River System represents in general a mountainous hydrographic network, with an average altitude 785 m above the sea level. Part of Albanian Hydrographic Network are lake system, Prespa-Ohri, and Scutary. A karstic phenomenon is very intensive in the limestone formation, which is extended in great surface of the country. The monitoring network has more than 22 meteorological and hydrometric stations, during the observed period 20–100 years.

Estimation of run-off discharge (Qi) are performed for two categories of river basins, with different hydrographical and hydraulical natural conditions:

1. Water system: Scutary Lake-Drini River-Buna River, where the run-off discharge Q_i is computed by $Q_i = F(H_i, Q_l)$, where Q_l represent the discharge of the lateral source.
2. Drini, Mati, Ishmi, Semani, Vjosa River systems, etc., where the run-off discharge Qi is computed by Qi-f(Hi), where Hi- level in the river Qi = f(Hi), where Hi is altitude of the water level river (i) section.

The hydrographical complex Scutary Lake-Drini River-Buna Riveris is very complicated and unique for its hydraulic regime, this particularity has made necessity of the estimation of the water flow of Buna River, based on hydraulic conditions:

The discharge of the Buna River, when it flows away from the Scutary Lake Q2 depends not only from the level of the water H2, but also on the level H2 and the Drini River discharge into the Buna River Q4. So, the only possibility to calculate the discharge of the Buna River Q2 is to find the connection Q2 = f(H2, Q4). The Q2 = f(H2, Q4) correspond to the results obtained through the hydraulic calculations the dependence Q3 = f(H3), topomorphometric data, and the hydraulic parameters of the rivers discharge are the basic dependence of this calculation. Giving standard values to the discharge Q_4 equal to 50, 100, 300, 1500 m^3/s and salving the dependence of Q_2 as an explicit function from the Scutary Lake level H_2 and the Drini discharge Q_4, it was made possible to from a single family of the countable curves of the Buna discharge in the Scutary Lake.

The phenomenon of dry and wet years has always had a significant role and great interest. All modeling and calculations have been performed for the model of dry and wet characteristic years, to analyze the climate impact on Albanian Hydro-graphic System.

Processes of the forming and circulation of the Adriatic Sea water mass have analyzed based on hydrographic data and Results of Albanian Marine Expeditions "Saranda 1963", "Patosi 1964" for the wet years (Pano 1974), and Italian—Albanian Expeditions "Italica I and II, 2000 and 2001" for dry years (Pano 2008).

72.3 Results and Discussion

The ground surface temperature (GST) history, yielded by tighter inversion of Ko- 10, at coastal plane region of western Albania, presents a gradual cooling of 0.6 K, before a middle of the nineteenth century (Fig. 72.1). Later followed by 0.6 K warming, with a gradient 5.4 mK/years, that seems quite reasonable and is consistent with generally accepted ideas about the climate of the last 2–3 centuries. GST history of boreholes, which are located in the mountainous regions of Northeast Albania, presents some changes, which are observed in these regions as to the cooling of 0.2 K during the nineteenth century. Later, was observed the warming trend of 0.6 K during the twentieth century, by a gradient 6.7 mK/year. Warming gradient increasing at

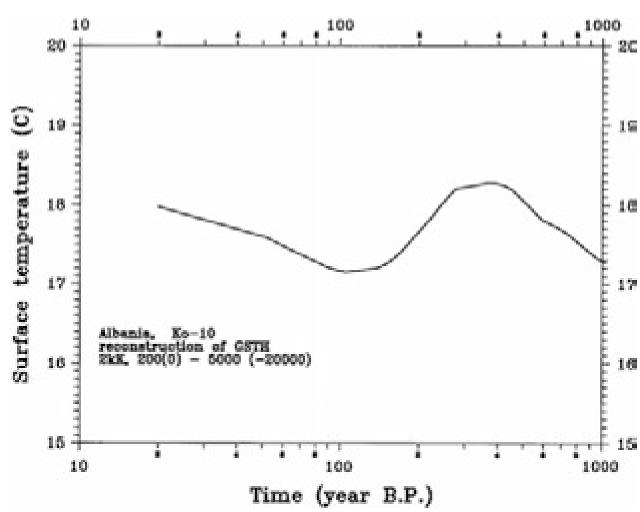

Fig. 72.1 Ground surface temperature history according to thermoplot of Ko-10 and Arza-31 wells

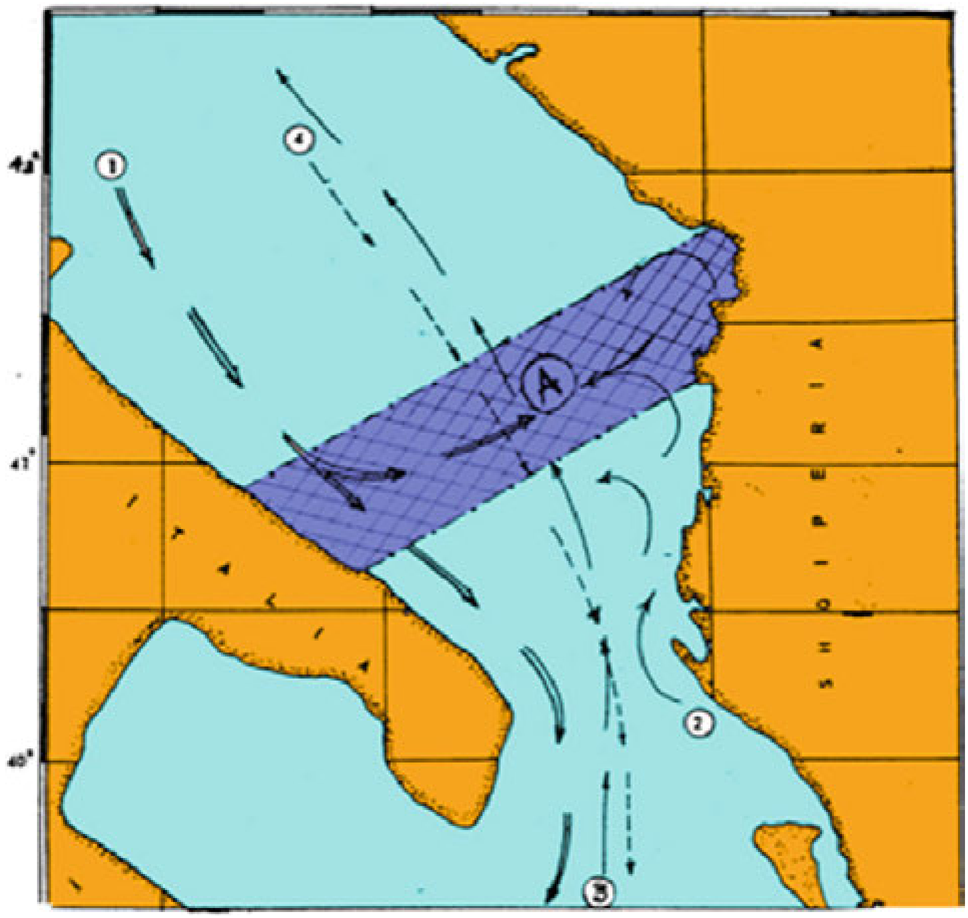

Fig. 72.2 "The Bridge" of continental water in the Adriatic Sea. 1. Adriatic deep water mass, 2. Eastern adriatic superficial water mass, 3. Intermediate levantine water mass, 4. Northern adriatic water mass

mountainous regions, in comparison with coastal areas, is caused by intensive deforestation during the last half of twentieth century.

Climate changes in Albania are observed also by the meteorological studies. Thirty quarter of twentieth century is characterized by a cooling of 0.6 °C, and later, up to present a warming of 1.2 °C. The warming trend is not a monotone one, in short intervals are observed cooling and warming (Boriçi and Demiraj 1990; Demiraj et al. 1996). Warming trend of maximum 1.2 °C, in particular after 70 years, is observed in all Albanian territory. Warming of the soil is more intensive than air warming.

The warming period in Albania is accompanied with changes of the rainfall regime, wind speed and wetness. There are observed a decreasing of the total year rainfall quantity, for about 200–400 mm. In the dependence of the geographical location of the areas changes the cross correlation of the rainfall quantity: Tirana area with Shkodra area $C_c = 0.62$, with Korga $C_c = 0.81$, Kugova $C_c = 0.66$, Kukesi $C_c = 0.88$, Gjirokaster $C_c = 0.88$, Vlora $C_c = 0.53$, during the period of 1930–1970. The warming have accompanied with decreasing of the wind speed about 1.5 m/s and 5 % increasing of the wetness, during the period of 1950–1994.

This warming is part of the global Earth warming during the second half of twentieth century. Its impact has been observed also on water systems and water resources. Inland water resources change has its impact on the hydrographic regime of the Adriatic Sea. These processes, in the particularly intensity of the penetration of the Levantine hot and saline waters in the Adriatic Sea through Otranto Strait, for long time period have been explained by the external phenomena from this sea. Has been supposed that Adriatic Sea doesn't participate in this penetration.

Based on two Albanian Oceanographic Expeditions have been collected data related to the mechanism of the forming and circulation of the Adriatic Sea water (Pano 1974, 2008).

The water potentials of Albanian rivers system is $Wo = 41.249.10^9$ m^3 that correspond to a mean annual discharge of $Qo = 1306$ m^3/s. So, Albania is one of high specific water potential in Mediterranean. The multi annual data have arguments that the total discharge of the Albanian rivers system in the Adriatic and Ionian Seas varies in very wide limits. Minimal discharge is 700–800 m^3/s for the hydrological dry years of low precipitation, up to maximal values 1900–2200 m^3/s for the hydrological wet years of high precipitation. Buna River is one of the most important rivers of the Mediterranean Basin. This river, together with

Po River in Italy, are determinant in the water balance of the Adriatic Sea.

The oceanographically situation of the wet years 1963–1964 has been characterized by formation of "The Bridge" with continental water in the Adriatic sea (Fig. 72.2). "The Bridge" is closely linked with the intensity of the river flow (Pano 1974). The eastern water mass are formed in SE Adriatic Sea area by the discharge of the Albanian rivers, and the Adriatic North water masses are formed by the discharge of Po River, Italy. This "Bridge", includes not only the surface layer, but also the Levant Intermediate Water (LIW) up to 600 m. depth. Low salt content and density of the seawaters are observed over "the bridge". This phenomenon has a complex and an important influence on many dynamics aspects of the formation Adriatic Deep Water (ADW), the deportation Levant Intermediate Water (LIW), and the monitoring mechanism of water into Otranto Street.

72.4 Conclusions

1. The climate at coastal plane region of Western of Albania was cooled of .6 K before of middle of nineteenth century. Later a warming of 0.6 K occurred, from last quarter of 19th until present-day. In northwestern mountainous region of Albania confirmed also a climate warming of 0.6 K during twentieth century.
2. The rainfall regime changes have their consequences in the fresh water resources of the country, of surface's and underground waters.
3. Warming has caused its impact on country climate and ecosystems. There is observed a decreasing of the water resources of the country, and thermal stress in the wetlands, lagoons and lakes.
4. The oceanographically situation in the Adriatic Sea is characterized from the formation of "The bridge" with continental water in the Adriatic Sea. "The bridge" is closely linked with the intensity of the river flow.

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Outlook on Seawaters Dynamics Factors for the Albanian Adriatic Coastline Developments

73

Pano Niko, Frashëri Alfred, Avdyli Bardhyl and Hoxhaj Fatos

Abstract

Results of integrated offshore and onshore hydrographical studies in Albanian Adriatic Littoral are presented in this paper. According to the geophysical and geological marine and onshore surveys, geodesic and bathy metric mapping has study different geomorphology and setting of Albanian Adriatic Shelf and coastline. Accumulative coastlines are extended at plain areas. Beautiful sandy beaches and dunes are main elements of these areas. Marine Quaternary deposits from plain sea floor up to some kilometres in the land have e thickness from some to hundred meters. Narta, Karavasta and Kune-Vaini Lagoons are located in plain area of the littoral. These lagoons are formed in some sea bays, which are closed by solid sediments transported by rivers to the sea. Erosive coastlines are extended in the hilly base of some capes. Sandstone banc are extended in the sea floor. Neotectonics development at the present has caused submergence of two sectors to the accumulative areas.

73.1 Introduction

The Albanian coastal area has its environmental individuality, and a perfect ecological balance. River mouths and deltas, lagoons system, abandoned riverbeds, inland, marsh labyrinths, sandy beaches, dunes covered with vegetation, dense forests represent an important and particular natural area of great international values.

Albanian littoral represent continuation of coastlines of two major paleogeographic zones: Erosion Coastline of Ionian tectonic zone in the southwestern part of Albania, and Adriatic Coastline of Peri-Adriatic Depression in the central and northwestern part of Albania. There are three different segments: Accumulative segments, erosive segments, and submerged areas, where is observed marine transgression toward the mainland.

The Adriatic coastline geomorphology and dynamics are conditioned by geological setting of the western side of Albanides, the neotectonic developments. Very important role has the dynamics of the seawaters and solid material solid discharge from Albanian River network to the Adriatic Sea, and their deposition along the coastal zone.

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73.2 Material and Methods

Albanian Adriatic Coastline developments study is based on integrated marine and onshore surveys results.

73.2.1 Hydrological and Hydro-Geomorphological

Studies represent the interpretation of the information of Albanian hydrometric network during the observed period of 20–100 years.

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73.2.1.1 Hydrological Studies

Temperatures, water levels and discharge into the Adriatic Sea, suspended material discharge; alluvial granulometric composition, chemical composition etc. were observed in main Albanian rivers. Estimation of run-off discharge (Qi) are performed for river basins with different hydrographical and hydraulic natural conditions.

73.2.1.2 Hydrogeomorphological Studies

Hydrogeomorphological studies were performed to evaluate the geomorphologic characteristics, evolution and migration of Albanian Adriatic coastline, The geomorphological regime of the Adriatic. Limnological observation on the Albanian lagoon system were performed in hydrometric stations in Butrinti, Karavasta, and Narta lagoons, by periodical expeditions.

73.2.1.3 Oceanographic Studies

Oceanographic studies have been carried out in 59 hydrometric stations. Oceanographic expedition were organized in the Southern Adriatic and Northern Ionian.

73.2.1.4 The Integrated Geological-Geophysical

Marine geological mapping and integrated offshore geophysical surveys have been performed using reflection seismic, electrical soundings and profiling, magnetic radiometric surveys.

73.2.1.5 Climate Change

Climate change was analyzed by ground surface temperature history, using the temperature record in the wells, and by the meteorological observations data.

73.3 Regional Hydrographic Outlook on the Albanian Littoral

The Albanian coastal area lies on the east side of the Southern Adriatic Sea, from Shengjini to Vlora bays and Northern Ionian Sea, from Vlora to Saranda bays at the south (Fig. 73.1). The coastal line length is 447 km. The water basin of this network is 43,305 km^2, from which 28,550 km^2 is inside of the Albanian state territory. Albanian River System represents in general a mountainous hydrographic network, with an average altitude 785 m above the sea level. The hydric resources of Albania are $41{,}249 \times 10^9$ m^3 water, which correspond to a module of 30 liter/s.1 km^2.

73.3.1 Adriatic Coastline

Adriatic coastline is lies over the Neogene Peri-Adriatic Depression, covered by Quaternary deposits, in western plain areas. Flattened accumulative coast is general characteristic of this coastline. There are also some marine caps with cliffed coast. The caps are located in the sectors where the Neogene molassic structures are abrupt by coastline and continues in the Adriatic Sea.

73.3.2 Outlook on Albanian Littoral Hydrology

The water flow of the hydrographic network of the Albanian rivers to the sea varies in wide limits. The discharge of the Albanian rivers into the Mediterranean Basin varies in very wide limits, from $Q_o = 700$–850 m^3/s for the hydrological years of a lower precipitation up to $Q_o = 1850$, 2150 m^3/s for the years of a higher precipitation. The volume of suspended material, which is transported through river network, is $65{,}7 \times 10^6$ ton/year, while the turbidity $Q_o = 1{,}260$ gr/m^3. The flow module of the suspended matter on the catchment surface of the Albanian rivers is R = 1,260 ton/km year. (Pano 1984). The river suspended matter deposits itself the river mouth in the Adriatic Sea. This process is very dynamic, making river's mouths very active. The period with the wave height of $H_1 = (0{,}1$–$0{,}2)$m represents about 80 % of the general cases, while the height of H = (0.2–4.5)m about 20 % of them for the average multi annual year. The highest waves have a direction from Northwest to West and a maximum wave height about h = 3.5–4.5 m near shore. Sea level has an average daily amplitude 0,30–0,40 meters and a multi annual maximal amplitude h = 1,14–1,53 m. Intensive winds with their maximal speed of 40–45 m/s. The average annual temperature of the water varies from t = 17,7–19,2°C.

73.4 Analyze and Results

73.4.1 Albanian Adriatic Coastal Areas

Adriatic coastal line has the marine accumulation flattened coast, the marine erosion coast, and the submerged areas.

73.4.1.1 Accumulative Areas Represents Main Part of the Coastline

Accumulative areas represents main part of the coastline are extended over the edge of western Albanian plains. This littoral is characterized by presence of the different genetic types Quaternary (Q) (Frasheri et al 1996, 1994; Thereska 1981). Sandy littoral belt along the accumulative littoral have a width up to 5 km. Sand dunes are situated along this belt. Sand dunes belts have a length of 25 km and an average width more of 50–100 m. Generally, the granulometry of quartzite sand deposits represented by fine sand. Very beautiful sandy beaches are extended in accumulative

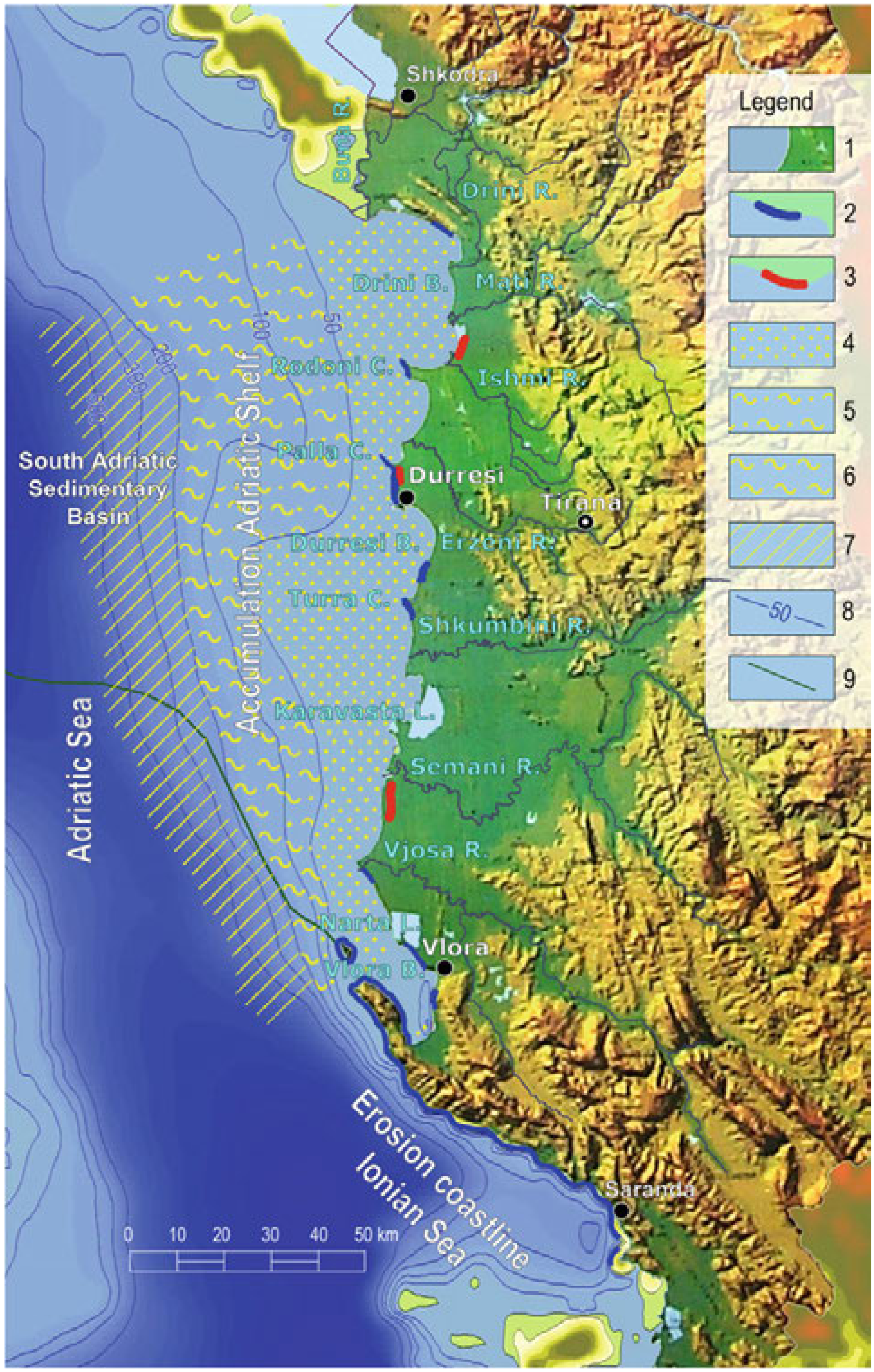

Fig. 73.1 Geomorphological Scheme of Albanian Adriatic and Ionian Seas coastline. (Digital Terrain Model, National Geophysical Data Center (NGDC), Geodas database, 2005. *1* Accumulative coastline; *2* Erosion coastline; *3* Submerged littoral zone; *4* Shoal shelf area with sand deposits; *5* Flat shelf area with sandy-silt deposits; *6* Inclined shelf area with muddy silt and deposits; *7* Continental slope with argillaceous sediments; *8* Isobaths; *9* Western flank of the South Adriatic Sedimentary Basin.1

coastal areas. In the accumulation coast the flat shelf sinks gradually up to the depth 100 m. Over there, the majority of deposits represents by sand and silt.

73.4.1.2 Erosive Zones

Erosive zones were developed in accumulation littoral of Adriatic shoal. In the erosion coast, usually, the sea bottom is sandy. Durrësi–Kepi Pallës area is one most typical erosive segment. Durrës-Kepi Pallës coastline is extended along the western flank of the Neogene molasses anticline. Western fold flank are lies under the Adriatic Sea waters. (Aliaj 1989; Frashëri et al. 1996). Zvërneci hilly zone is located at northwestern direction of Vlora Bay. The Tortonian molasse Zvërneci hills chain from the isle separated Narta lagoon from the Adriatic Sea.

73.4.1.3 Submerged Areas, Where is Observed Marine Transgression Toward the Mainland

Semani beach at western Albanian region and Patoku beach in the southern side of the Shwngjini Bay represent submerged areas within accumulative coastline. Submerged process is caused by the neotectonics activity, consequently there are observed a marine transgression (Aliaj 1989). In Semani beach coastal water line has a ingression of 305 m toward the mainland, with a gradient 9.4–8.1 m/year.

Second submerged area is observed at the Patoku beach, between Ishmi River Mouth at the south and Mati River Mouth at the north. During the period 1972–2012 coastal water line has a ingression of 175 m toward the mainland.

73.4.1.4 Lagoon Area

Lagoon area has a total surface of about 150 $km^{2,}$ while the volume over 350-million m^3 water. The most important lagoons are those of Karavasta, Narta, Butrinti, Viluni etc. Albanian lagoons represent crypto-depressions, with the floor under the level of the sea's bottom. The lagoons represent the new lakes. Its creation started during Pliocene Period, some 4–5 million years ago, and its creation lasted during the Quaternary Era till our days.

73.4.2 Impact of the Climate Change on Adriatic Sea Hydrology

Ground Surface Temperature history according to the geothermal studies presents a climate change influence. Generally, during the first half of twentieth century, the climate worming for about 1°C is observed. Thirty quart of this century has been characterized by a cooling for 0.6 °C. Later, up to present a worming for 1.2 °C is observed (Frasheri et al. 2004; Pano et al. 2001). Climate changes in Albania are observed also by the hydrometeorological studies (Albanian Climate 1978; Demiraj et al. 1996). The warming period in Albania is accompanied with changes of the rainfall regime., wind speed and wetness. There are observed a decreasing of the total year rainfall quantity, for about 200–400 mm. Inland water resources change has its impact on the hydrographic regime of the Adriatic Sea (Pano 2008).

Based on two Albanian Oceanographic Expeditions has been proposed a mechanism of the forming and circulation of the Adriatic Sea water (Pano 1975, 1984, 2008). The multi annual data have arguments that the total discharge of the Albanian rivers system in the Adriatic and Ionian Seas varies in very wide limits. Minimal discharge is 700–800 m^3/s for the hydrological dry years of low precipitation, up to maximal values 1900–2200 m^3/s for the hydrological wet years of high precipitation. Buna River is one of the most important rivers of the Mediterranean Basin. This river, together with Po River in Italy, are determinant in the water balance of the Adriatic Sea.

73.5 Conclusions

- Albanian Adriatic coastline has an intensive change and continuously modifying its shape.
- Submerged process, caused by neotectonic activity, is observed in some sectors within accumulative Adriatic coastline.
- The climate at coastal plain region of Western of Albania has a warming of 0.6 K occurred, from last quarter of nineteenth until present-day. These climate changes have their impact on country water system, on and water resources, on the erosion processes, and on the hydrographic regime of the Adriatic Sea.

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Climate Change Impact on Buna River Delta in Adriatic Sea

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Abstract

In the paper are analyzed impact of climate change, and hydrologic characteristic of the river and sea: Buna River runoff discharge, water mass circulation in Drini bay, wave refraction, sea level and incursion of the high tide waves, coastal accumulation and erosion processes et al that are conditioned hydro-geomorphologic development of the delta of Buna River. The morphology and hydro-geomorphologic development dynamics of the Buna River Delta are conditioned by hydrological regime of the river, thalassographic regime of the Adriatic Sea, and climate change impact.

Keywords

Delta • Ground temperature • Climate changes • Hydrographic system • Adriatic sea

74.1 Introduction

Albania is a subtropical zone. To the east, in the mountain areas, the climate is Mediterranean mountainous. The climate in Albania varies from a region to the other. The climate change studies are based on geothermal inversion results and meteorological observation data. There is analyzed the ground surface history (GSH) and paleoclimate change according to the temperature recorded in the different wells in Albania. Climate changes during the last half of the twentieth century has been analyzed also based on the meteorological data. There are estimated continental water flow, created by atmospheric rainfalls and its impact on processes of the forming and circulation of the Adriatic Sea water mass has been analyzed. In the second part of the paper, is presented the analysis of climate change impact on Buna River Delta in Adriatic Sea.

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74.2 Materials and Methods

Climate changes are analyzed in two directions: firstly by temperature record in the deep wells and shallow boreholes, and secondly by the meteorological observations data. The ground surface temperature reconstruction for long period, about 5 centuries, has been performed by estimation of the ground surface temperature changes at the past, according to the present-day distribution of the temperature at the depth, recorded in six boreholes, which are located at the plain and mountain regions. The study of geothermal field of Albania has been carried out based on the temperature logging in the wells and boreholes (Cermak et al. 1996;

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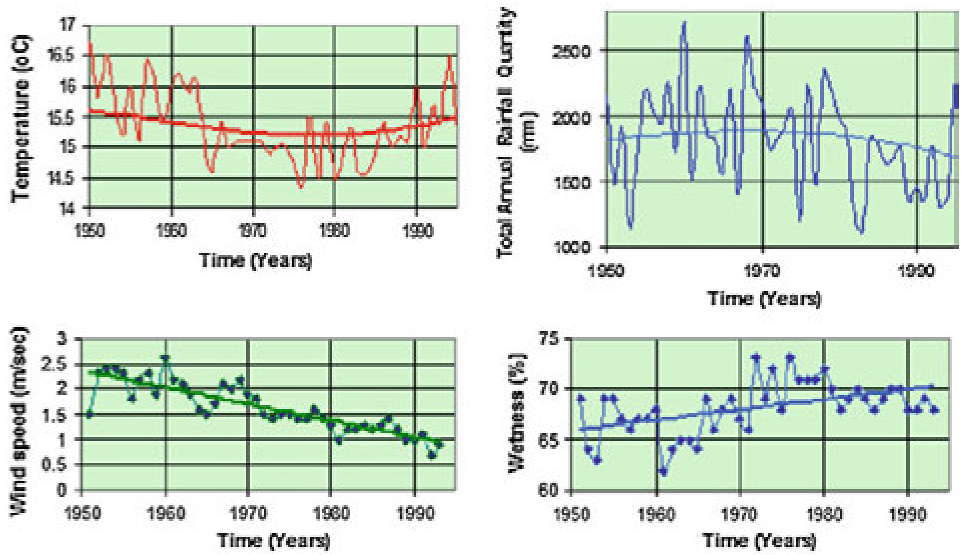

Fig. 74.1 Air average annual temperature, total year rainfall quantity, wind speed and wetness variations, at Shkodra meteorological stations (Period 1950–1994)

Frasheri et al. 1995, 2004). Air and ground temperatures, total annual rainfall quantity, wind speed and wetness, which are analyzed by records in Meteorological Stations (Fig. 74.1) (Albanian Climate 1978; Borifi and Demiraj 1990; Gjoka 1990; Mici et al. 1975, the data for 1985–2000 after Mustaqi V.).

Water potential of the Albanian Rivers System have been evaluated by a specific way (Pano 1967, 1995, 1998), based on the multi annual archival data (Hydrometeorological Institute of the Academy of Sciences of Albania) have calculated the annual runoff discharge of the Scutary Lake-Buna River-Drini River System, according to the corresponded types of the water supply, structure of the annual discharge distribution. All modeling and calculations have been performed for the model of dry and wet characteristic years, to analyze the climate impact on Albanian Hydrographic System. Processes of the forming and circulation of the Adriatic Sea water mass have analyzed based on hydrographic data and Results of Albanian Marine Expeditions "Saranda in 1963", "Patosi in 1964" (Pano 1967), and Italian-Albanian Expeditions "Italica I and II, 2000 and 2001" (Pano 2008).

74.3 Results and Discussion

Buna River is important part of the hydrographic complex "Scutary Lake-Buna River-Drini River". Delta of the Buna Rives is located in Drin Bay at Adriatic Sea. This delta presents one of more active and interesting area of the Mediterranean Sea.

The ground surface temperature reconstructions of the thermoplots of Kolonja-10 deep wells, which are located at coastal plain region of western Albania presents a gradual cooling of 0.6 K, before a middle of the nineteenth century. Later followed by 0.6 K warming, with a gradient 5.4 mK/years, that seems quite reasonable and is consistent with generally accepted ideas about the climate of the last 2–3 centuries. GST history shows that warming gradient increasing is observed also at mountainous regions.

Climate changes in Albania are observed also by the hydrometeorological studies. Figure 74.1 present graphics of yearly average temperature of the air in Shkodra Meteorological Stations, for the period from 1931 to 2004. In general, the end of first observes half twentieth century, a warming of climate, about 10 °C (Borifi and Demiraj 1990).

Thirty quarter of twentieth century is characterized by a cooling of 0.6 °C, and later, up to present a warming of 1.2 °C. The same climate changes are observed also at Shkodra City. The cross correlation coefficient is $Cc = 0.78$ between variation curves of the average annual temperatures of both of these stations. Warming trend of maximum 1.2 °C, in particular after 70 years, is observed in all Albanian territory. The warming have accompanied with decreasing of the wind speed about 1.5 m/s and 5 % increasing of the wetness, during the period of 1950–1994.

This warming is part of the global Earth warming during the second half of twentieth century. Its impact has been observed on water systems and water resources. Inland water resources change has its impact also on the hydrographic regime of the Adriatic Sea (Pano 1984, 1994, 2008). There are great impacts of the specific natural conditions of the Albanian Hydrographic System catchment in particular of the Scutary Lake-Buna River-Drini River System.

Buna River maximal flow (respectively discharge (QM p%) and volume (WMp%) for different probabilities ($p = 0{,}01$; 0,1; 1; 2; 5; 10, 20 %) is presented in Fig. 74.2. Maximal flow with a probability $p = 1$ % (one in

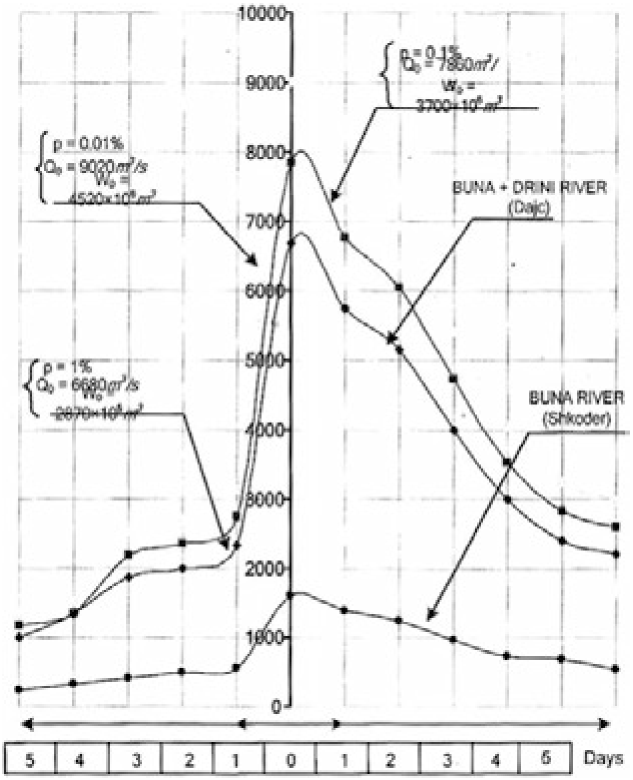

Fig. 74.2 Maximal flow, Buna + Drini River-Dajg

100 years) has the discharge QMp = 1 % = 6680 m2/s and a volume WMp = 1 % = 2870.106 m3.

The average annual sea level is H = 0,12 m on the 0" absolute level. In the multi annual period the maximal level with the probability of p = 1 % on the Albanian offshore is Hmax = 1,2 m on the 0" absolute level, while the minimal level is Hmin = −0,5 m Abs. as the results the maximal amplitude of the sea level during the multiannual period is AH = (Hmax-Hmin) = 1,62 m. The most eventual waves observed during the year in the Drini Bay are h = 0,6–1 m (33 % of the cases). Same important ones are also the following: h = 1,6–3,1 m (20 % of the cases). The one of the h = 3,5 m have are not observed very often, about 0,3 %. Their principal directions are S, SW, NW, and S. The maximal waves in marine shelf: height h = 5,10 m, length L = 80,6 m, velocity C = m/s and period T = 7,2 s. Minimal discharge is 700–800 m^3/s for the hydrological dry years of low precipitation, up to maximal values 1900–2200 m^3/s for the hydrological wet years of high precipitation.

Buna River is one of the most important rivers of the Mediterranean Basin. This river, together with Po River in Italy, is determinant in the water balance of the Adriatic Sea.

Climate change and variation of the discharges have its impact on the marine water mass flows and solid material transport in the time, velocity and locations, and also on the wave regime. Consequently, in the Buna delta during the short period for about 37 years (1972–2009) are developed intensive erosion, and in the both side of the coastline an accumulation process. In the Buna River Delta actually is formed a marine spit.

Ecosystems, and biodiversity, in the particularly in the water's flora and fauna have an important influence from climate change. Temperature augmenting has caused increasing of the evaporation in the water systems. Consequently in the river system, reservoirs, wetlands, lakes and lagoon system has been observed thermal stress. In very beautiful ecosystems of Albanian lagoon as Kune-Vaini in Lezha region etc. thermal stress has its impact, first of all on the biodiversity. This stress is extended also in the shallow coastal waters; consequently there are observed diminution of the fish quantity.

74.4 Conclusions

1. The climate at coastal plain region of Western of Albania was cooled of 6 K before of middle of nineteenth century. Later a warming of 0.6 K occurred, from last quarter of 19th until present-day. Temperature records in northwestern mountainous region of Albania confirmed also a climate warming of 0.6 K during twentieth century. Warming, mainly during the last quarter of the twentieth century, is demonstrated also by meteorological data.
2. Warming has caused its impact on country climate and ecosystems. There is observed a decreasing of the water resources of the country, and thermal stress in the wetlands, lagoons and lakes of Albania. Impact it is observed first of all on the biodiversity.
3. The rainfall regime changes have their consequences in the fresh water re-sources of the country, of surface's and underground waters.
   In the Buna delta during the short period for about 37 years (1972–2009) are developed intensive erosion and in the both side of the coastline an accumulation process.
4. Geomorphologic change of the coastline it is necessary to evaluate during the urban planning of the coastline.

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THERMAL WATER OF CARBONATE ROCKS AQUIFERS OF ALBANIA

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Tirana, 2014

INTRODUCTION

In the paper are presented:

1- Geological-structural, thermal and hydro-chemical characteristics of thermo-mineral waters of carbonate rocks aquifers in Albania.

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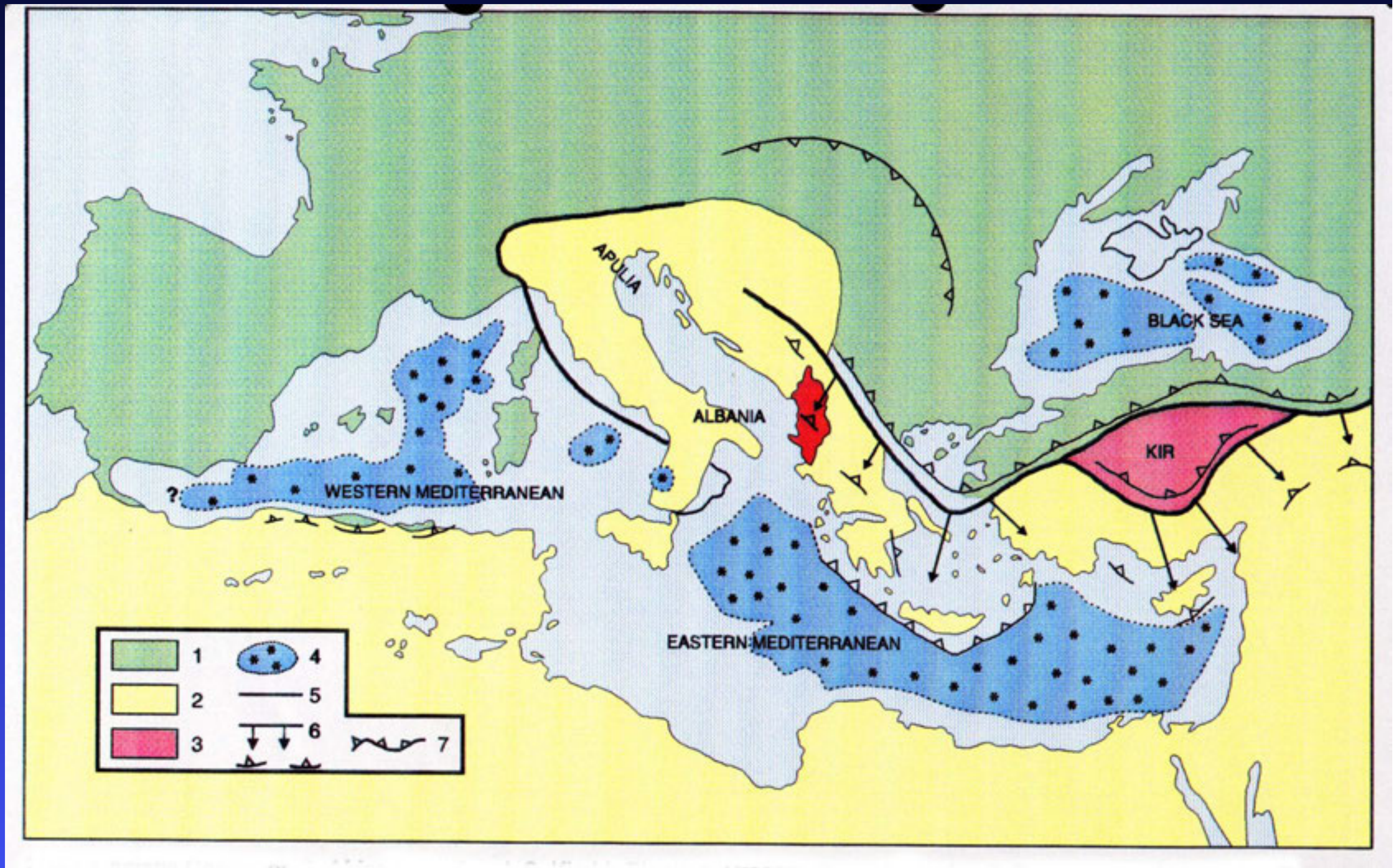
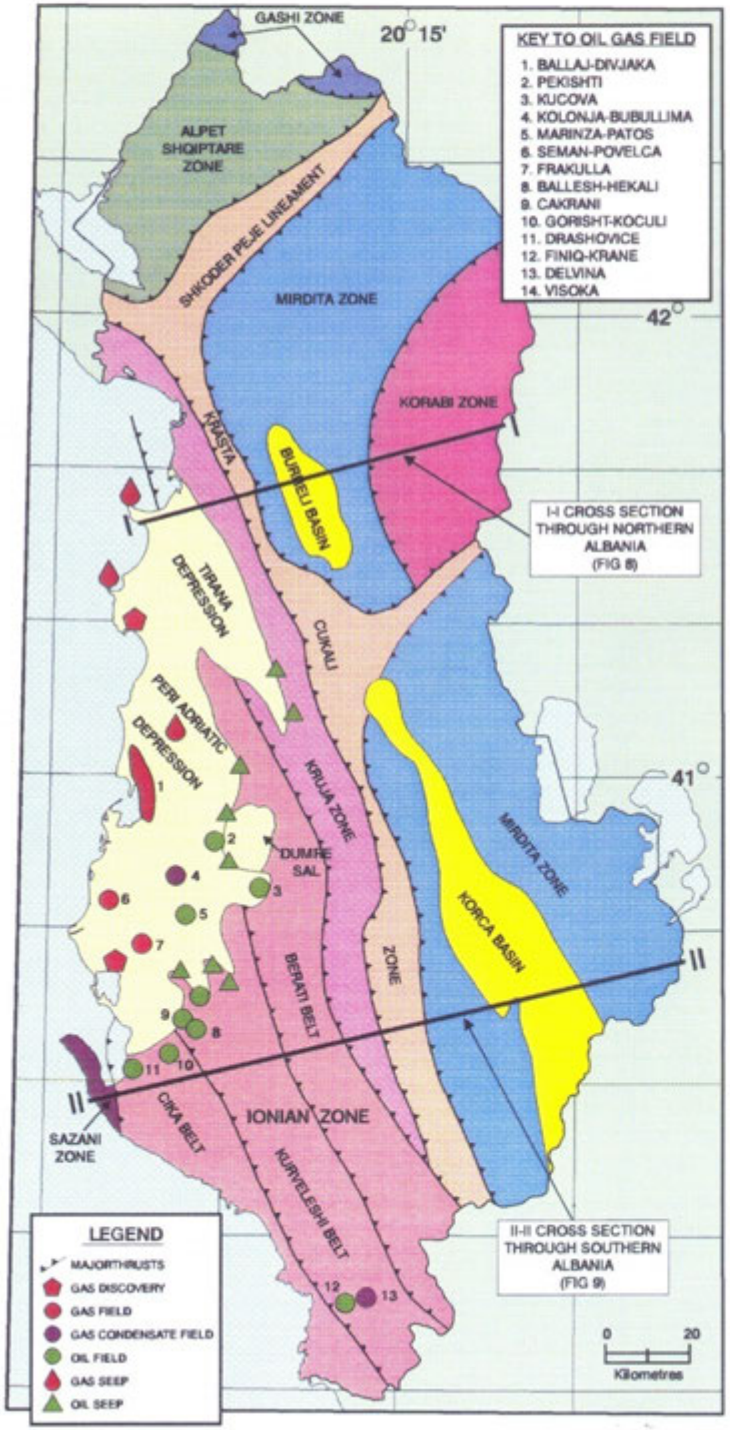
The **ALBANIDES** represents part of southern branch of Mediterranean Alpine Belt



Two major paleogeographic domains form the Albanides.

- <u>The Internal Albanides</u> formed part of the Subpelagonian Trough.
- <u>The External Albanides</u> was developed out of the western passive margin and continental shelf of the Adriatic plate.



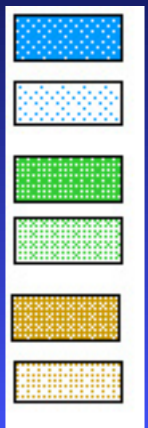
Peri-Adriatic Depression Depression as a part of Albanian Sedimentary Basin, continued towards the shelf of the Adriatic Sea.

The geological cross-section of Albanian Sedimentary Basin is about 15 km thick.

The structures of the Albanides are typically alpine, with SSE-NNW general strike. The structures are asymmetrical. Generally, their western flanks are affected by disjunctive tectonic. Recumbent, overthrusted and overtwisted structures are found, too.

Mineral water basins

Although Albania is a small country, his regional hydrogeological picture is very heterogeneous. The complex geological-structural and geomorphologic conditions of Albania have resulted in aquifer's heterogeneity concerning their resources, hydrodynamics and hydro-chemical characteristics (Eftimi 2010).



I Porous aquifers
- **Ia Highly productive**
- **Ib Low productive**

II Karstic and fissured aquifers
- **IIa Highly productive**
- **IIb Moderately product**

III Insignificant aquifer
- **IIIa Local and limited aquifers**
- **IIIb Essentially no groundwater**

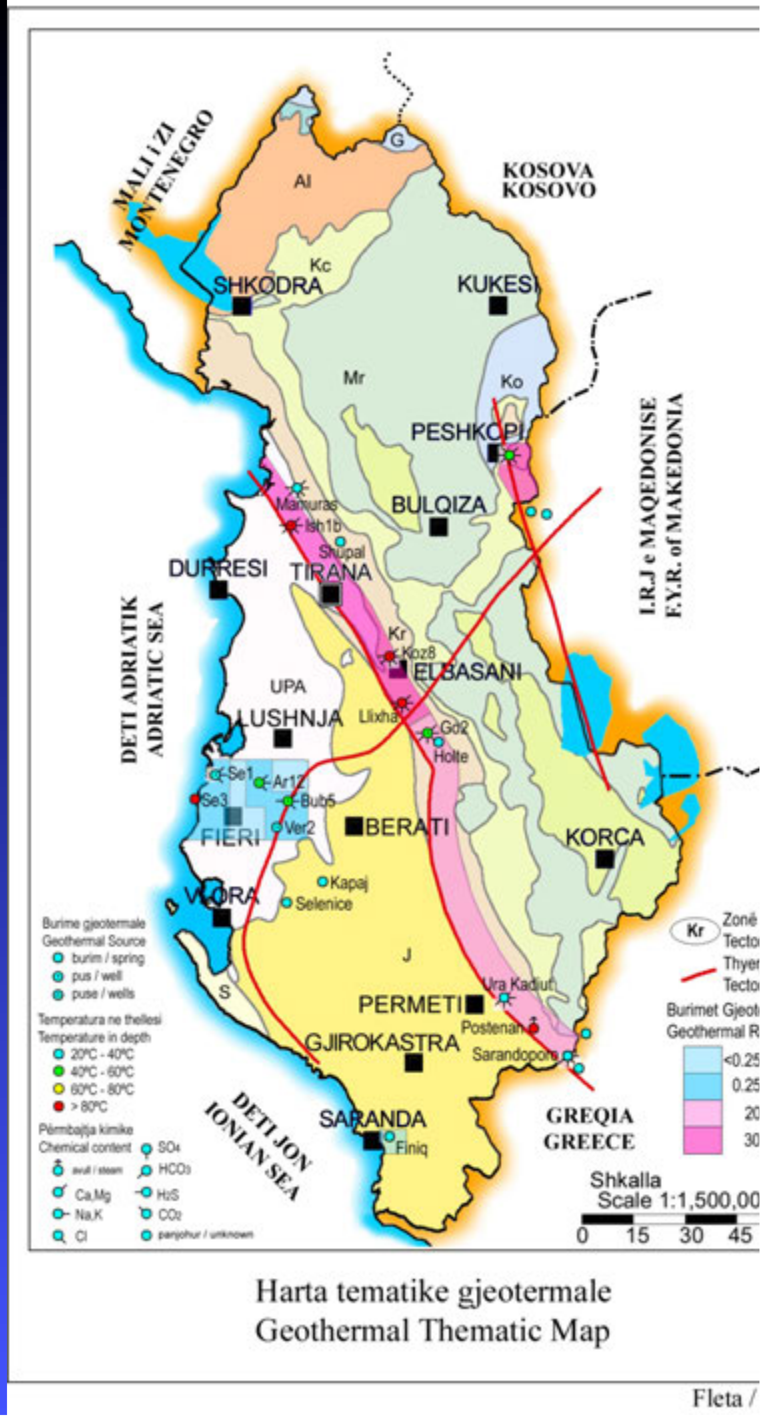
The thermal and mineral waters of Albania are located in four thermo-mineral provinces:

a) Peshkopi province;

b) Kruja province;

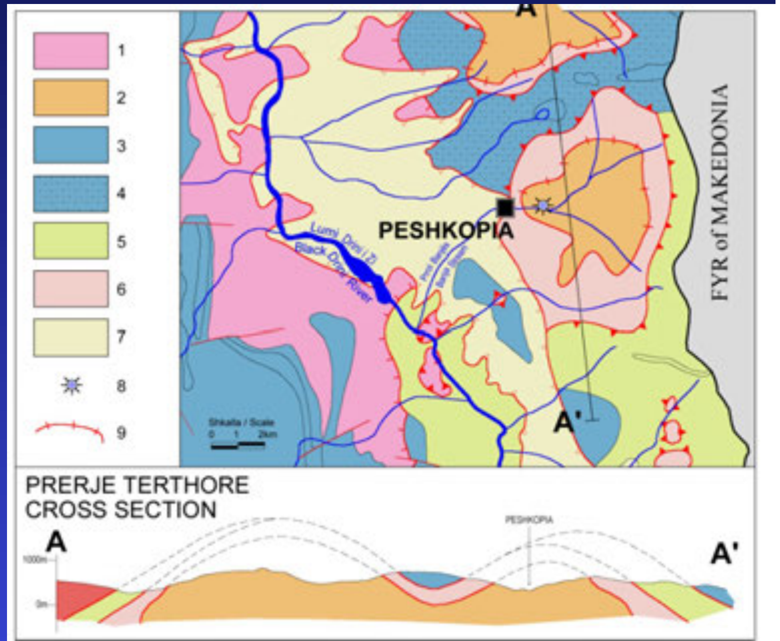
c) Preadriatic basin province, and

d) South Ionian province.



Peshkopia province

Represents the central part of Korabi zone which is characterized by the presence of two tectonic windows where gypsum dome structures outcrop.

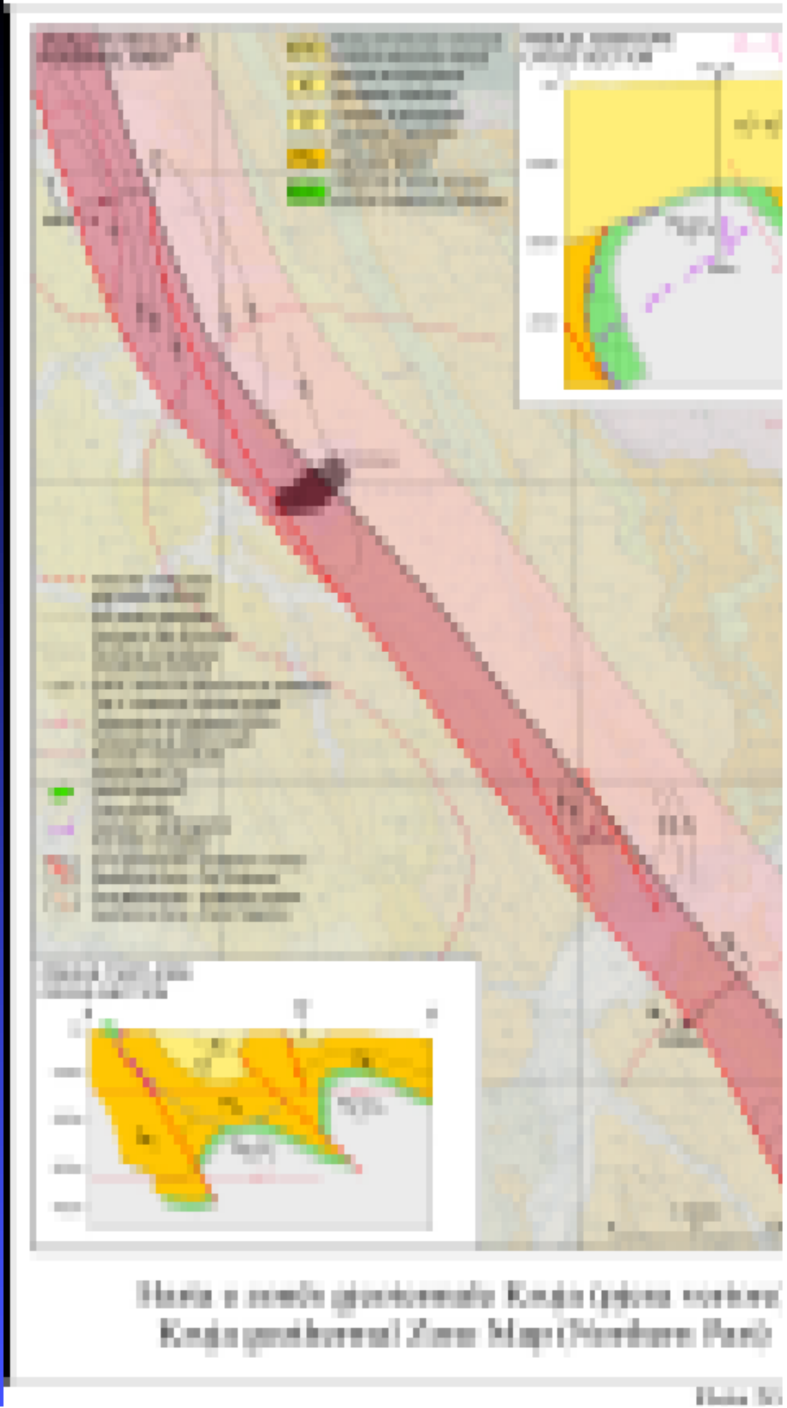


- Two important sulfur thermo-mineral springs known as Peshkopia spa, appear at south western tectonic contact of gypsum with surrounding Paleogene flysch formations.
- The formation of the springs is related to the deep fault developed along the Black Drin River.
- Hydrochemical type SO4-Ca ,

T= 35° C to 43.5° C and Q= 13 l/s.

Kruja province

- In the northern part of this province, is developed the Tirana artesian basin, hosting two type of aquifers:
- a) Mesozoic-Paleogene carbonate rocks. water temperature 60° C, chemical type is Cl-Na and the H_2S gas content is more than 1000 mg/l
- b) Neogene molasses rocks. Water temperature lower than 30° C.
- A particular geothermal phenomenon is the Postenan steam spring
- Identified resources of Kruja geothermal province in carbonate reservoirs are 5.9×10^8-5.1×10^9 GJ.



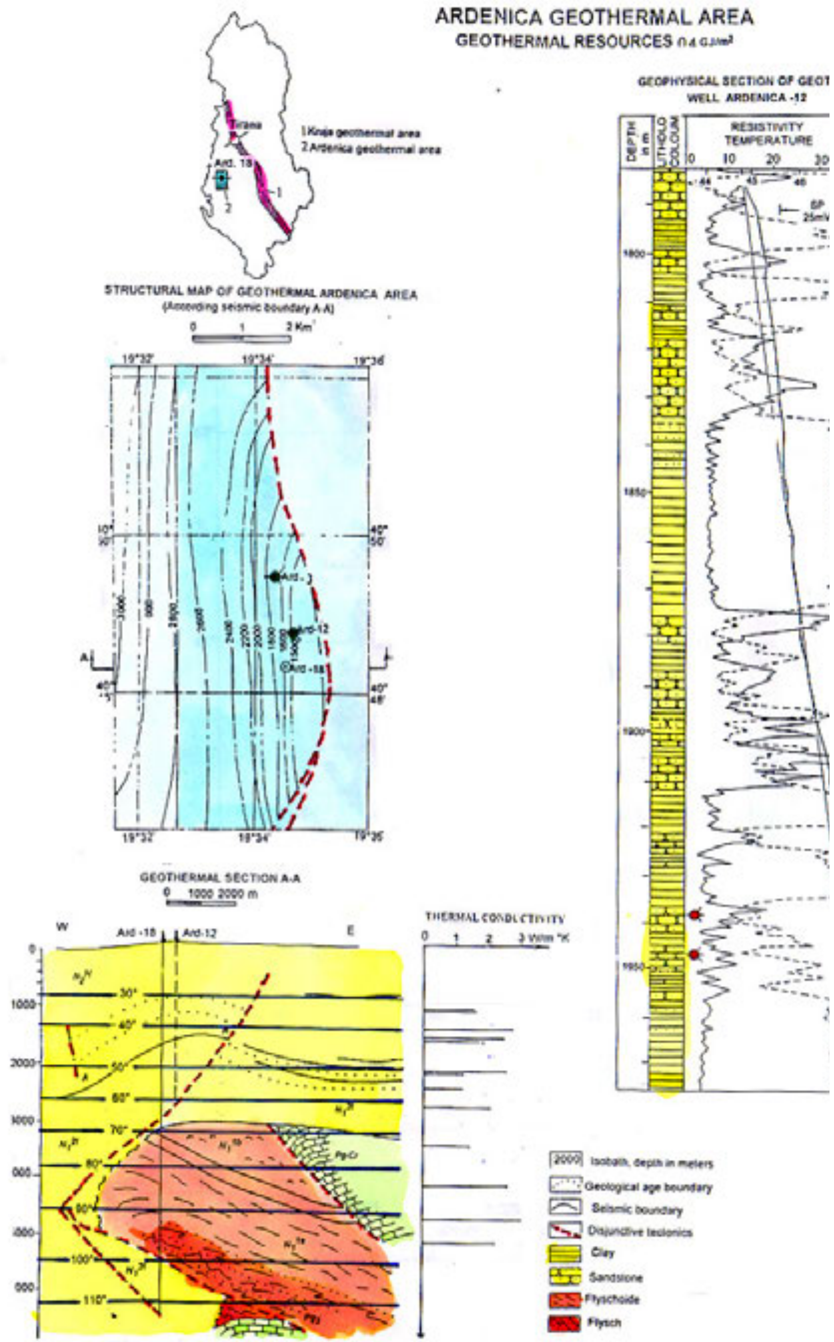
Preadriatic basin province

Represent an artesian basin., with three aquifers:

a) The deep aquifer of carbonate rocks; water of high temp. mineralizatio of Cl-Na type.

b) The intermediate aquifer of sandstone Neogene molasses, Water temp. 32-83° C; mineralization 38-55 g/l, and the chemical type is Cl-Na, CH_4 gas.

c) The upper aquifer of Pliocene sandstone-conglomerate formations.



South Ionian province

- Is the widest geothermal province of Albania, but not the richest. This province consists of some carbonate anticline,

- In this province is not known the presence of thermomineral springs. From the carbonate rocks, only big fresh water spring issue. Only in some deep wells have free flowing high temperature about 30 oC, and highly mineralized groundwater.

- The well Grekan-4, situated near the Dumre gypsum dome, at the depth about 1200 m fountain the groundwater with temperature 35° C, mineralization about 325 g/l, and brome content of about 768 mg/l;

GEOTHERMAL REGIME

Temperature

The geothermal field is characterized by a relatively low value of temperature.

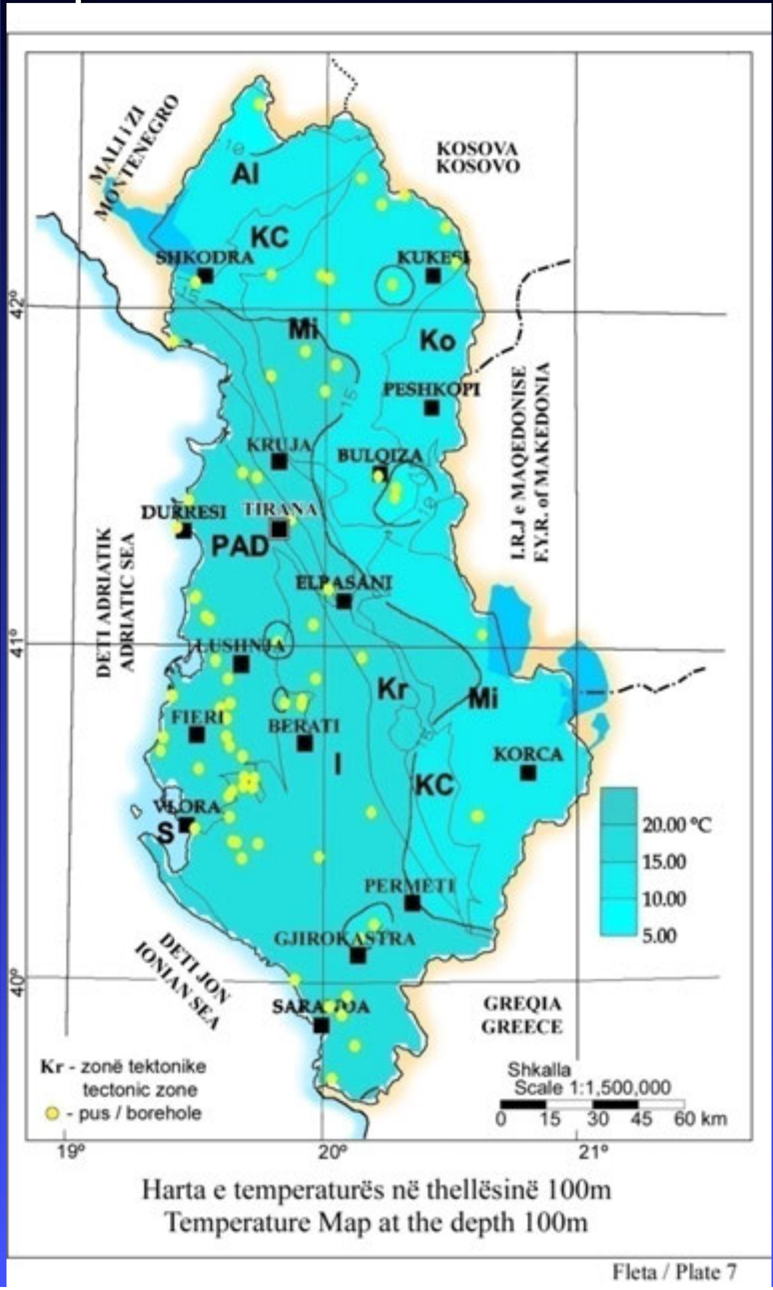
At 6000 meters depth, the temperature is 105.8^{o}C, in the central part of the Peri-Adriatic Depression.

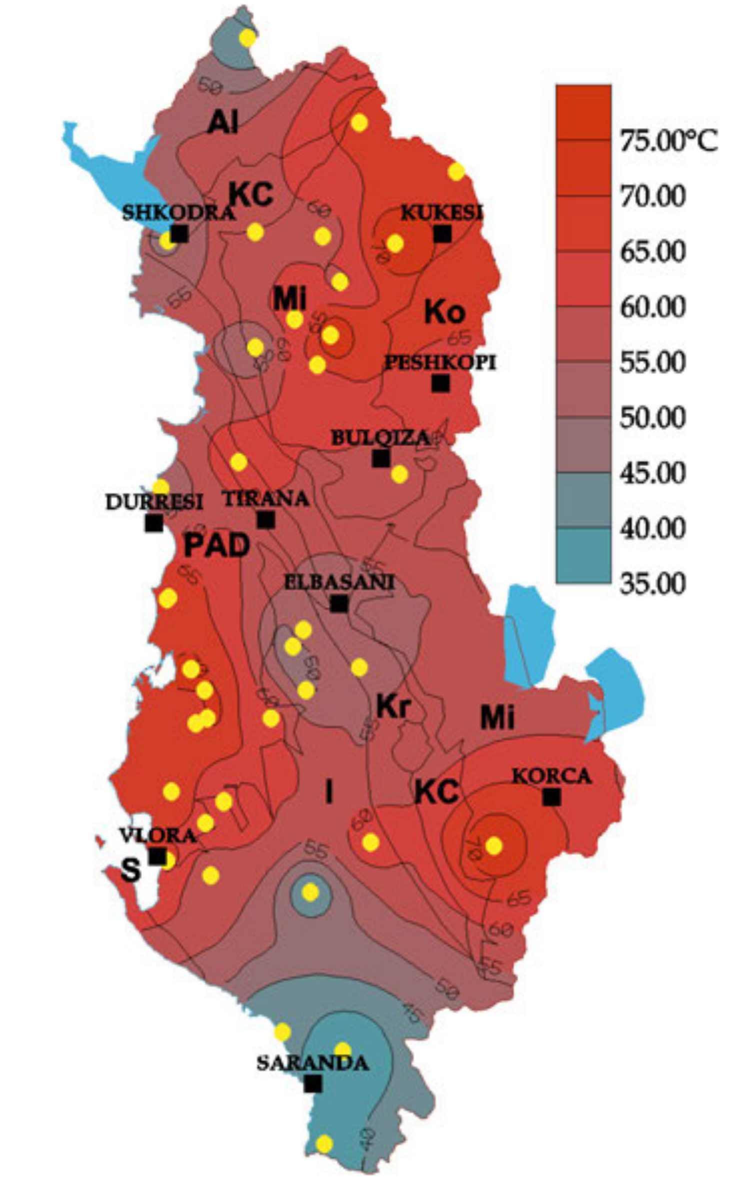
The lowest temperature values have been measured in mountain regions. In these areas, there is intensive circulation of cold underground water, of 5-6^{o}C temperature.

Generally, the isotherms run fit well to the strike of structures of the Albanides.

The temperature at 100 meters depth varies from 8 to 20^{o}C

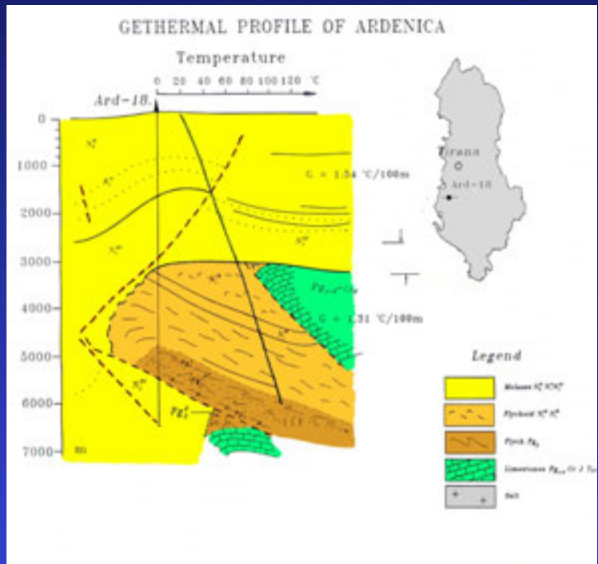
The highest temperature at 3000 m is 68 oC

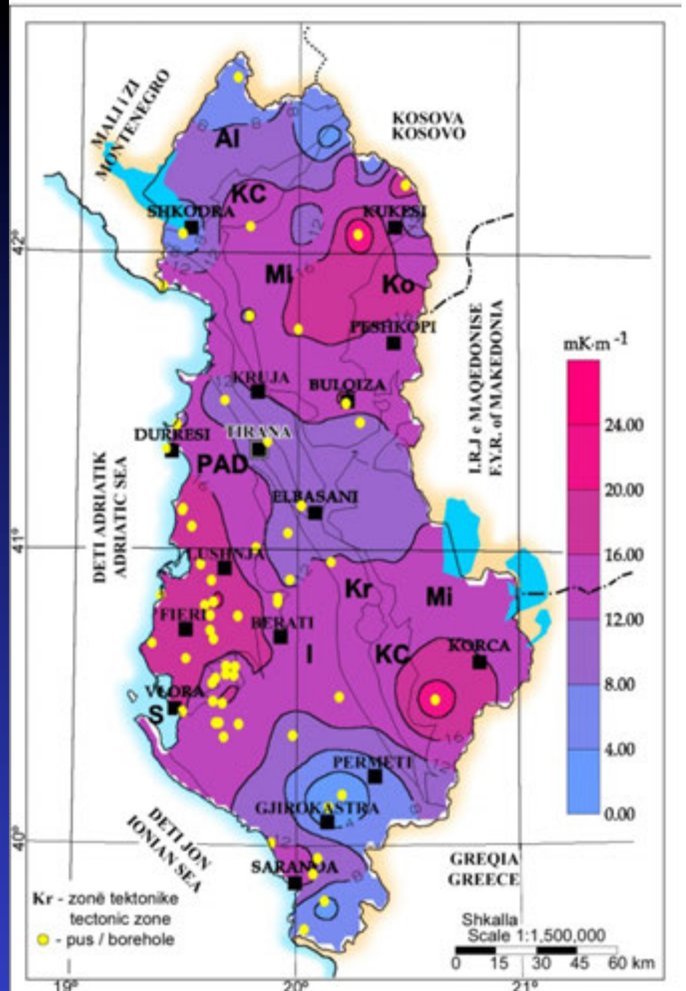




GEOTHERMAL GRADIENT

Geothermal Gradient changes from western to the eastern part of the Albania, and in the depth.



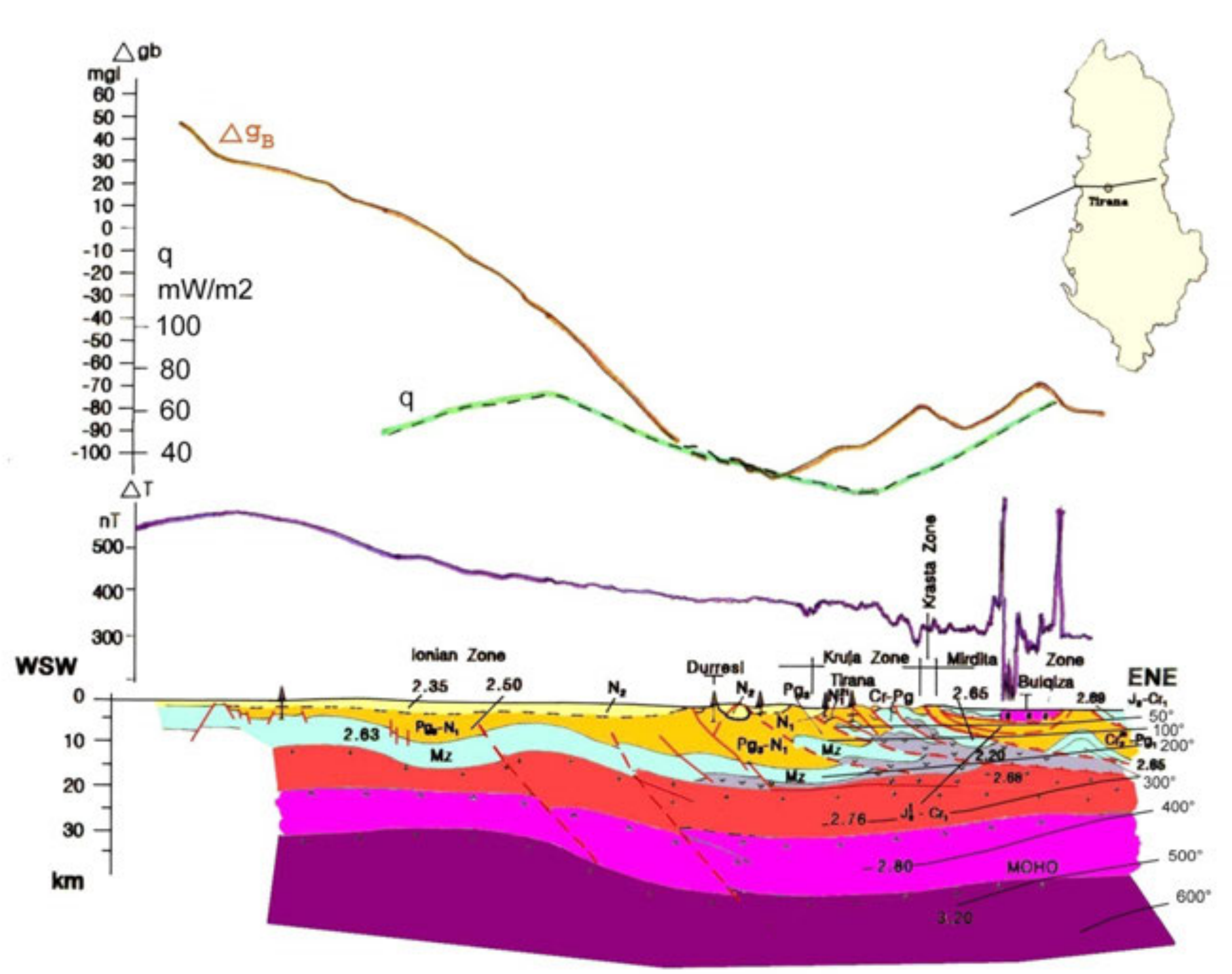


Harta e gradientit gjeotermal mesatar
Average Geothermal Gradient Map

Fleta / Plate 13

External Albanides are characterized by low geothermal gradient from 15 to 21.3 mK/m. Deeper than 20 km is observed decreasing of the gradient. This change of the gradient is coincided with the top of the crystal basement.

Regional Geological- Geophysical Profile Albanid-1, Falco- Durrës-Tiranë-Peshkopi



Are observed that the temperatures in ophiolitic belt are higher than in the sedimentary basin, at the same depth.

The geothermal gradient has a value up to 36 mK/m at northeaster and southeastern part of the Albania.

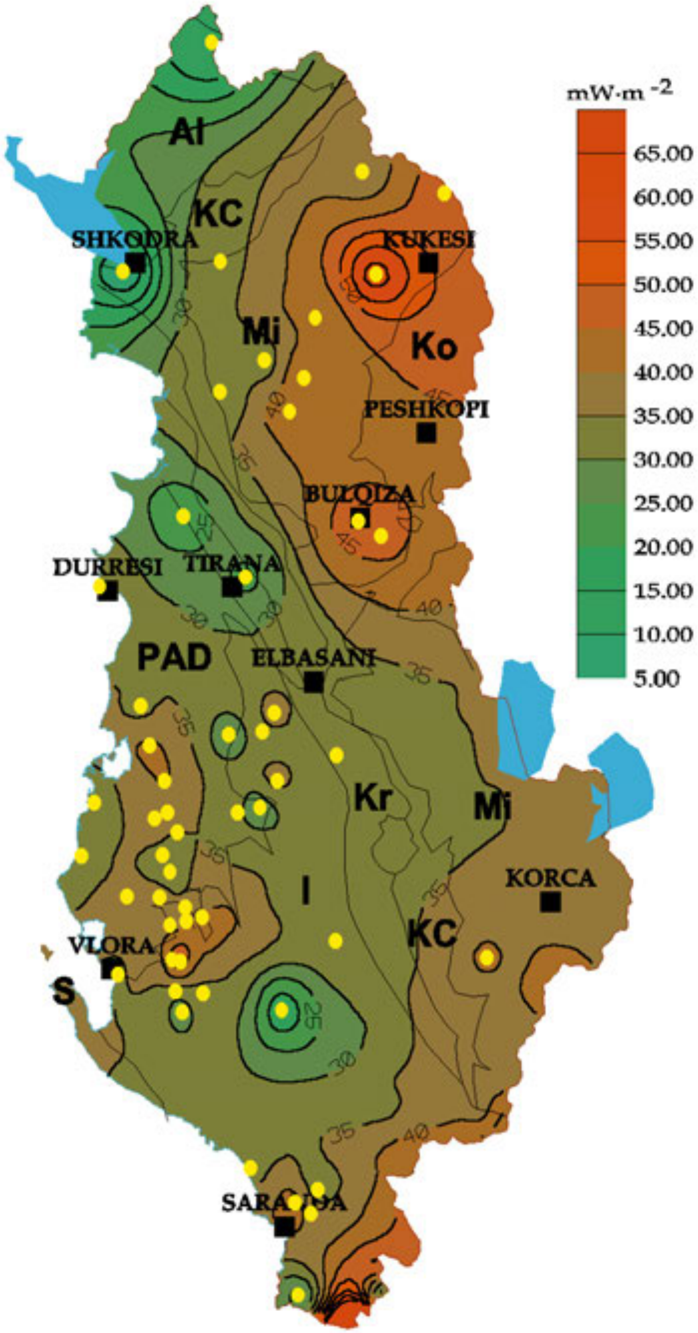
Decreasing of the gradient are observed deeper than 12 000 meters in this side of Albania, at the top of the Triassic salts deposits.

HEAT FLOWW DENSITY MAP OF ALBANIA

In the External Albanides is maximal value of the heat flow is equal to 42 mW/m^2.

In the ophiolitic belt at eastern part of Albania, the heat flow density values are up to 60 mW/m^2.

The granites of the crystal basement, which have the possibilities for the great radiogenic heat generation represents the heat source.
In ophiolitic belt, is observed decreasing of the MOHO discontinuity depth.



Heat flow anomalies are conditioned by intensive heat transmitting through deep fractures. **These fractures are responsible for the location of the geothermal energy sources.**

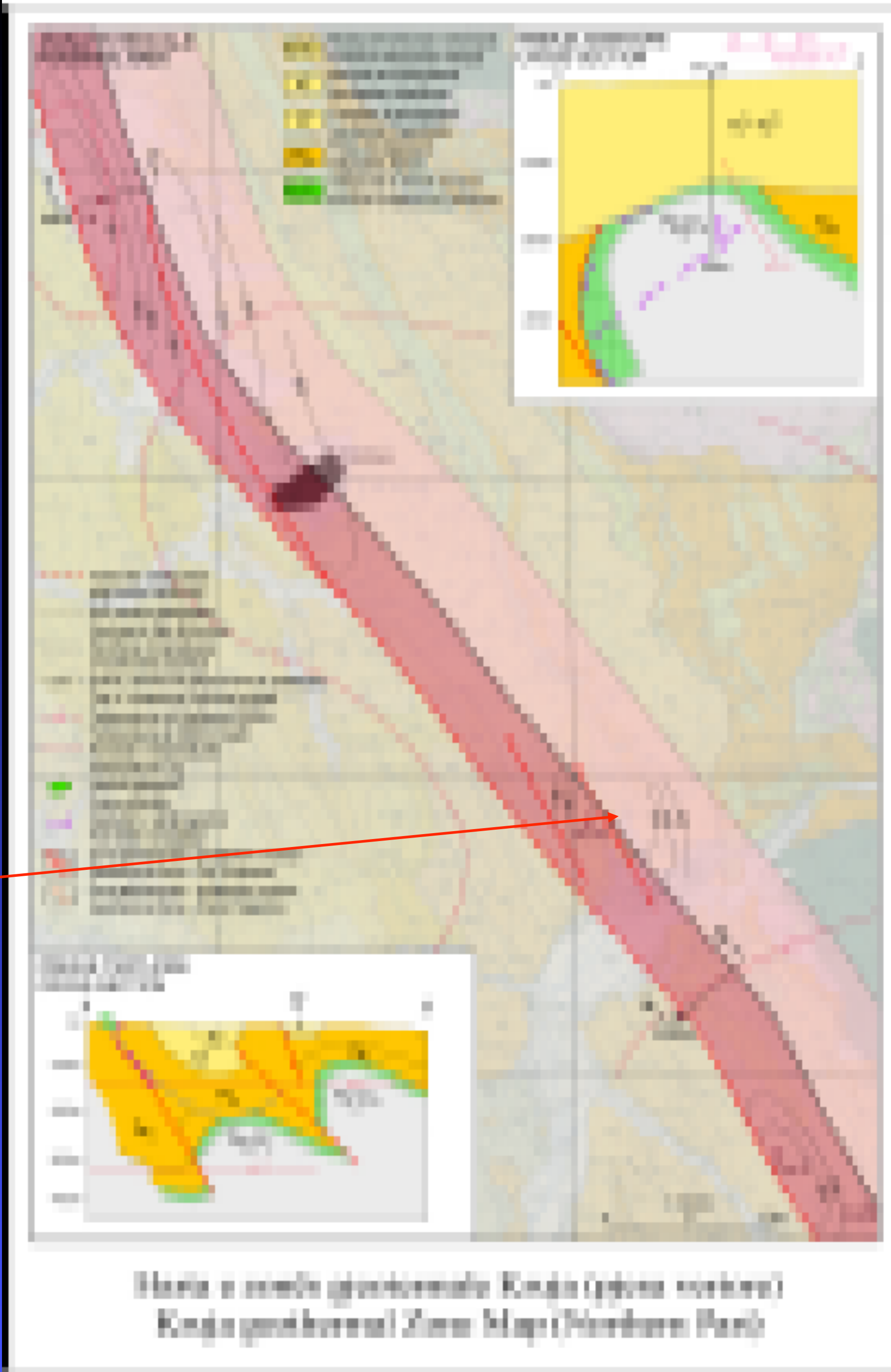
According to the calculation of different geo-thermometers, the aquifer temperatures vary fromre 144 up to 270°C. Based on the geothermal modeling, one can suppose that thermal waters rises from 8-12 km deep, where temperature attains to 220°C.

GEOTHERMAL SPRINGS AND WELLS MAP OF ALBANIA

Thermal wells

Thermal springs

NORTHERN PART OF KRUJA GEOTHERMAL ZONE



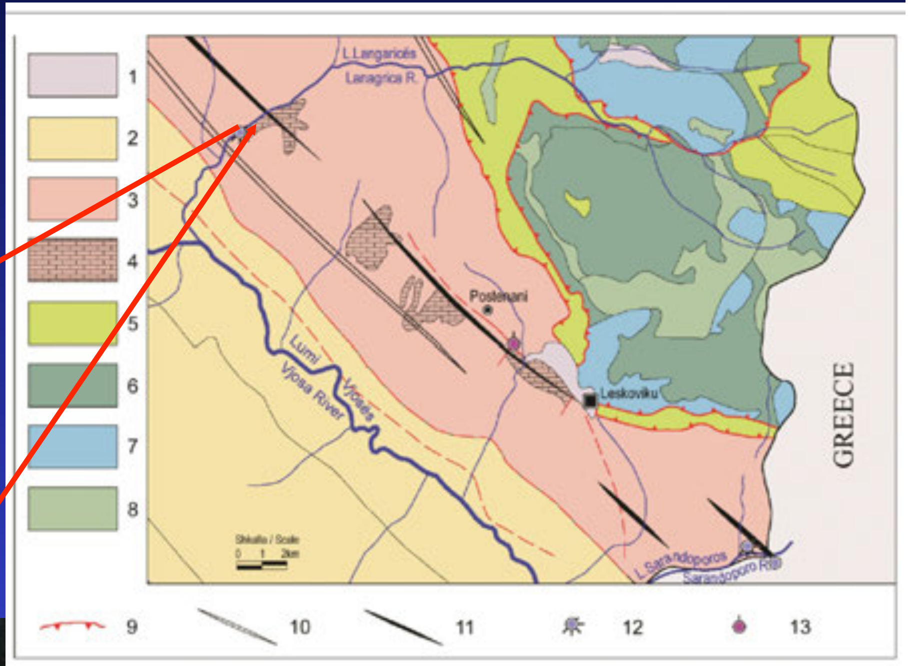
Llixha Elbasan spar

SPA “NOSI”

Postenani steam springs

SOUTHERN PART OF KRUJA GEOTHERMAL ZONE

BENJA THERMAL SPRINGS



Ph=185kW COP=4,1

Thermal waters of springs and wells in Albania may be used in several ways:

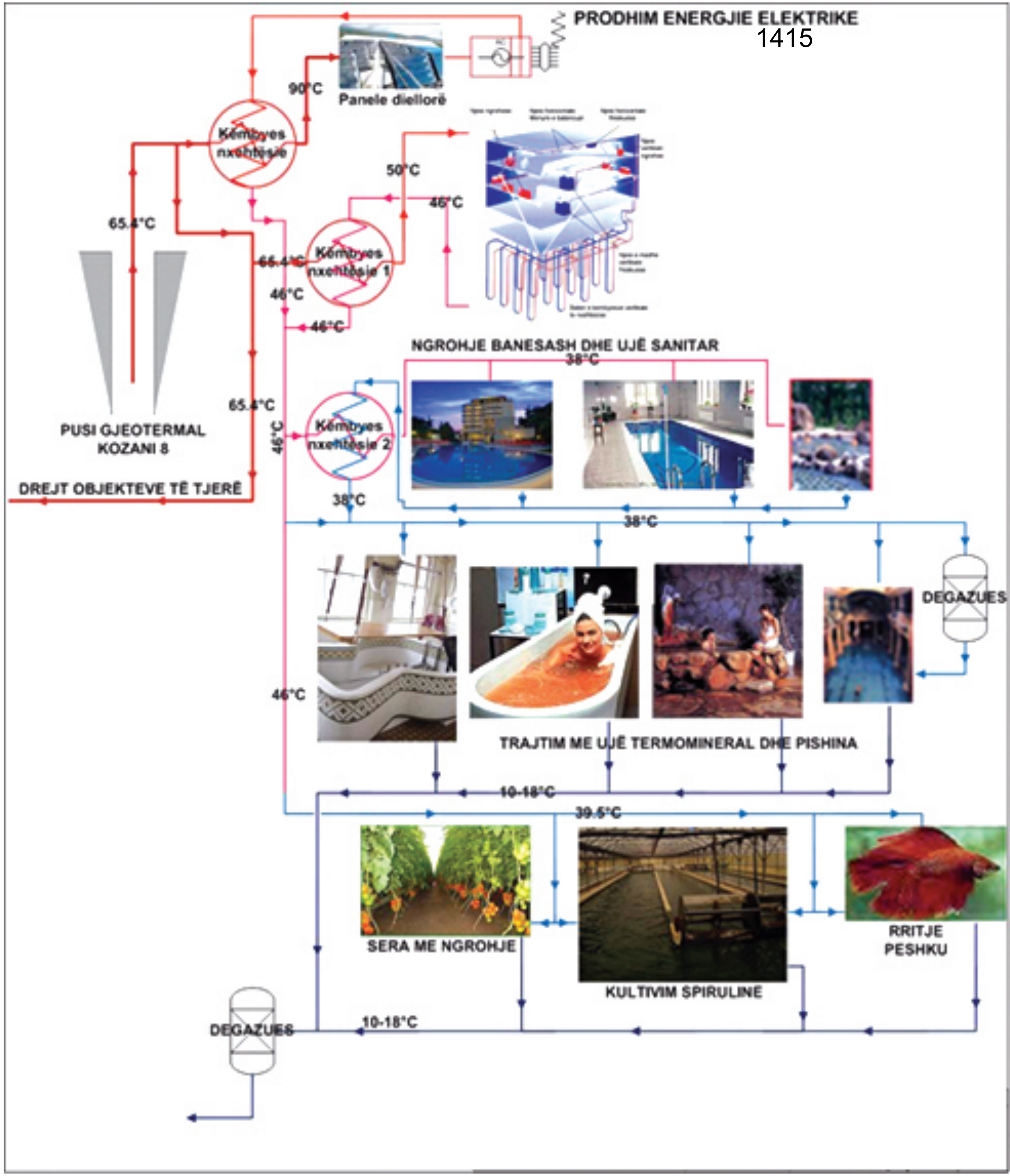
The geothermal situation of low enthalpy in Albania offers different directions for use of geothermal energy, which is unused until now.

This exploitation will realized by:

-Integrated scheme of geothermal energy, heat pumps and solar energy, and

-cascade use of this energy

-Modern SPA-WELLNESS with thermal pools for treatment of different diseases, recreation, relax and development of eco-tourism.



Integrated and cascade use of thermal waters of Kozani-8 deep well:

1. **Power-generation**:
   Thermal water (80 oC) heated by solar panels up to 100 oC.

2. **Direct use:**

SPA-WELLNESS
- Space heating
- Sanitary water
- Thermal pools
- Thermal bath, sauna

AGRICULTURE
- **Green houses**

ACQUACULTURE
- Fish
- Spirulina

DEGAZING, SALTS EXTRACTION.

From thermal mineral waters of some spring and wells it is possible to extract very useful chemical microelements as iodine, bromine (Ardenica wells), chlorine etc. and other natural salts, so necessary for preparation of creams for the treatment of many skin diseases as well as for beauty care products.

From these waters it is possible to extract sulphidric and carbonic gas. It is possible to built installations for processing of mineral waters.

CONCLUSIONS

- In Albania four provinces of thermomineral waters are distinguished.

- Based on the chemical data, the thermomineral waters could be classified into three most relevant types:

  - The SO_4-Ca type, reach in H_2S gas occurs in the areas of gypsum deposits,

  - The mixed Cl-SO_4-Na-Ca gas types reach in H_2S occurs in limestone sediments underlined by gypsum deposits of Kruja and Ionian provinces.

  - The Na-Cl type reach in CH_4 gas underground waters are related to molasses sediments of Adriatic basin province.

- The highest measured temperature of thermomineral water of Albania is 83° C, but the temperature calculated by the geothermometers results more than 200° C.
- The resources of geothermal energy of low enthalpy of Albania could be integrated and cascade direct use as an alternative energy.
- Resources of the geothermal energy in Albania are: high temperature springs (temperature up to 65.5° C), as well as shallow groundwater and bedrocks, with have an average temperature about 16.0° C, and depth Earth Heat Flow.
- Installation of the space-heating system, using shallow borehole-heat exchanger-Geothermal Heat Pumps systems present the most important direction of the use of geothermal energy.

THANK YOU VERY MUCH FOR YOUR ATTENTION

INTERNATIONAL SCIENTIFIC CONFERENCE
INTEGRATED COASTAL ZONE MANAGEMENT IN THE ADRIATIC SEA

Institute of Marine Biology, Kotor, Montenegro
29 September – 1 October 2014

REMOTE SENSING ANALYSIS OF THE ADRIATIC SHORELINE MOVEMENTS

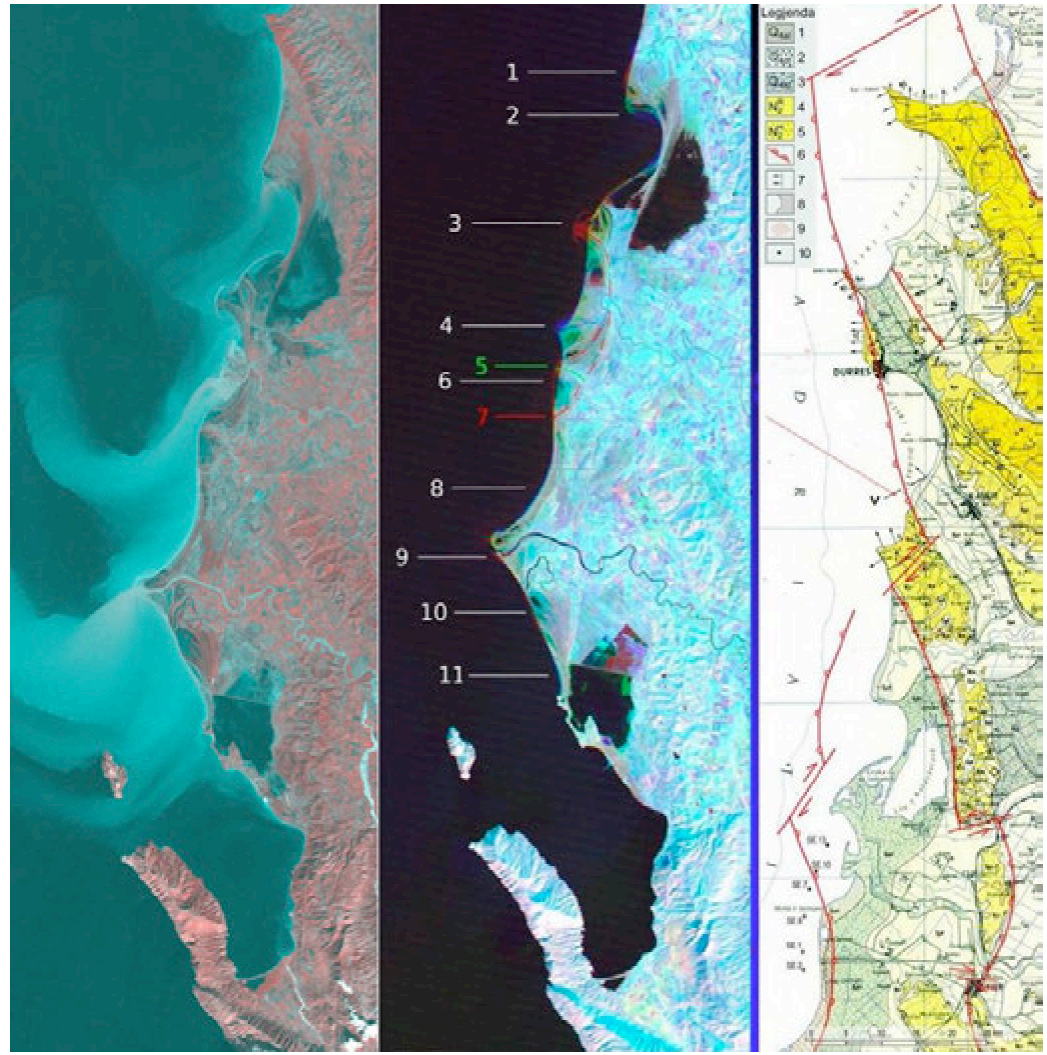
Frasheri N., Beqiraj G., Bushati S., Frasheri A., Taushani E.

Academy of Sciences of Albania

Introduction

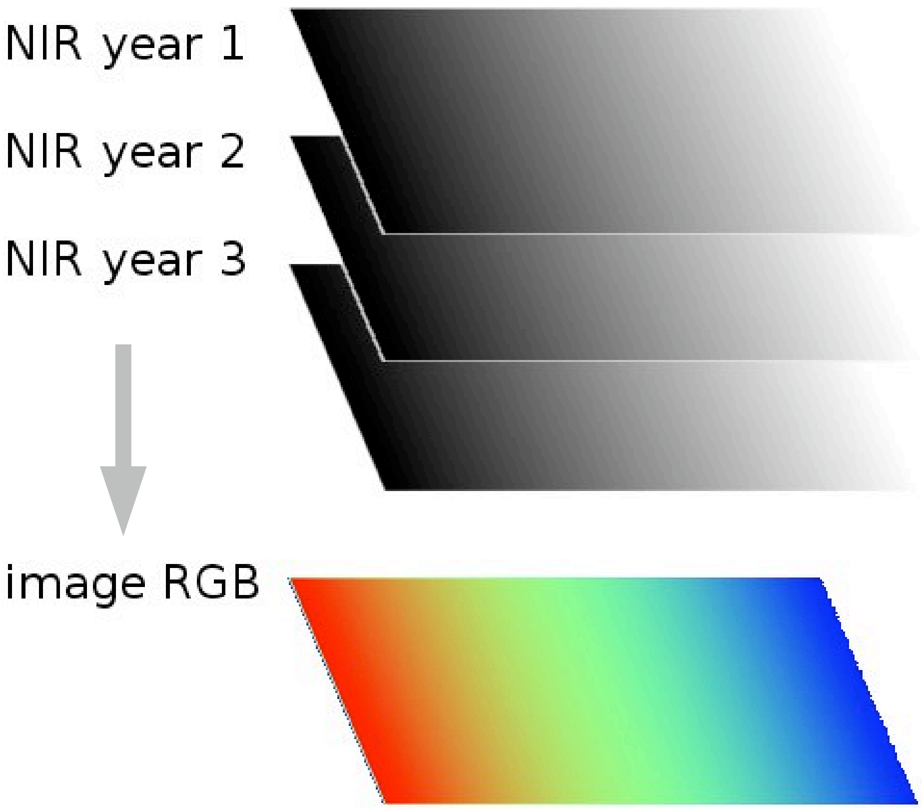
Albanian Adriatic Sea shore is subject to dynamic geomorphologic changes, including accumulation, erosion, and submersion in different segments.

These geo-morphological littoral changes have impacted the landscapes and economic activities

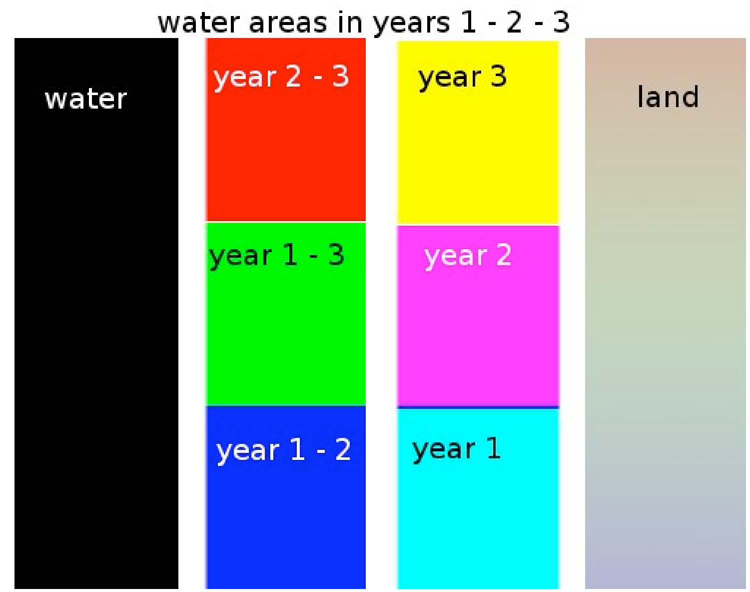


The Methodology

- Landsat NIR bands from different years (1973 – 89 – 92 – 2002) combined in single false color RGB image



- Water areas remain black
- Land areas remain 3-colors
- Changed areas appear 1-color or 2-colors

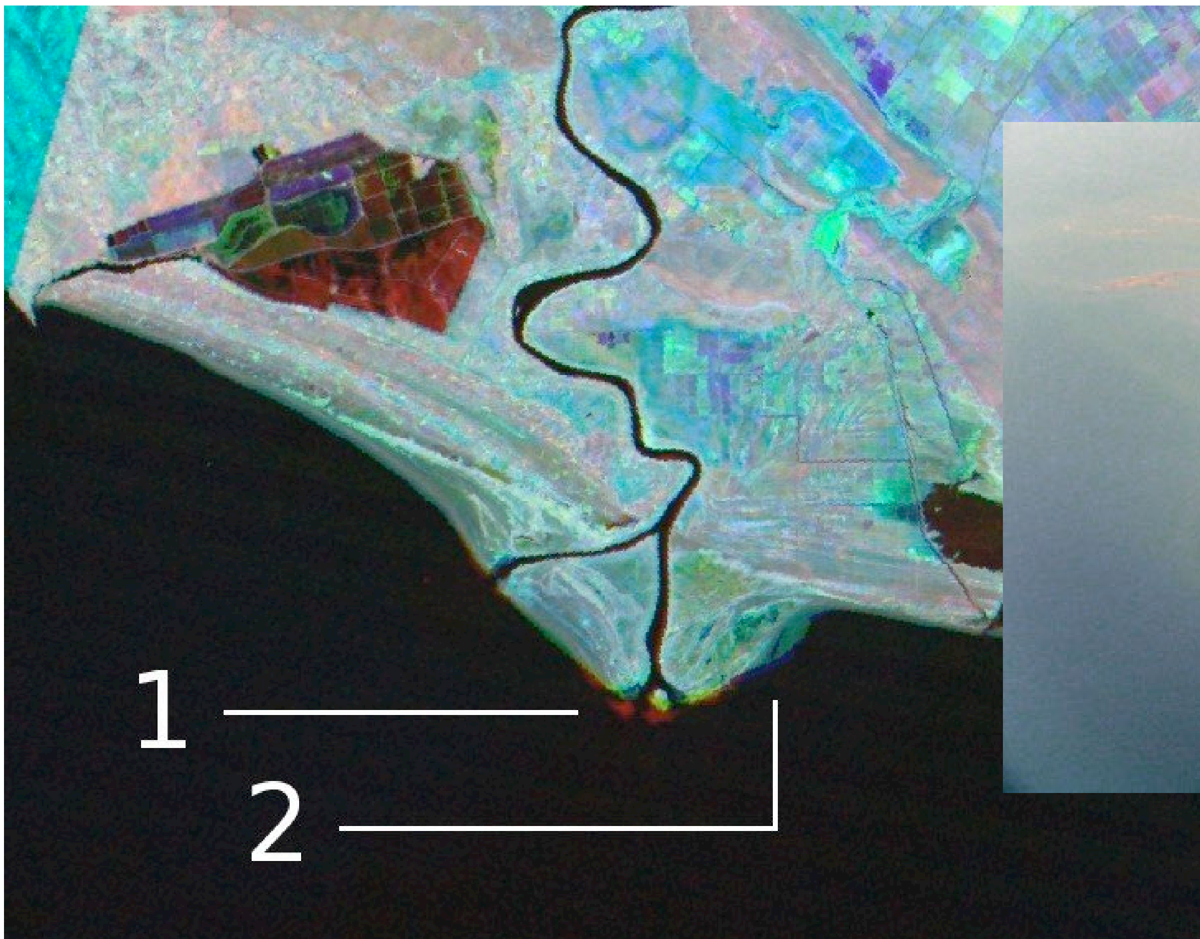


Adriatic shoreline North to South

- Buna River Delta
- Velipoja beach
- Shengjini / Drini Bay
- Mati River Delta
- Lalzi Bay
- Durresi Bay
- Shkumbin River Delta
- Semani River Delta
- Karavasta Lagoon
- Vjosa River Delta
- Narta Lagoon
- Vlora Bay

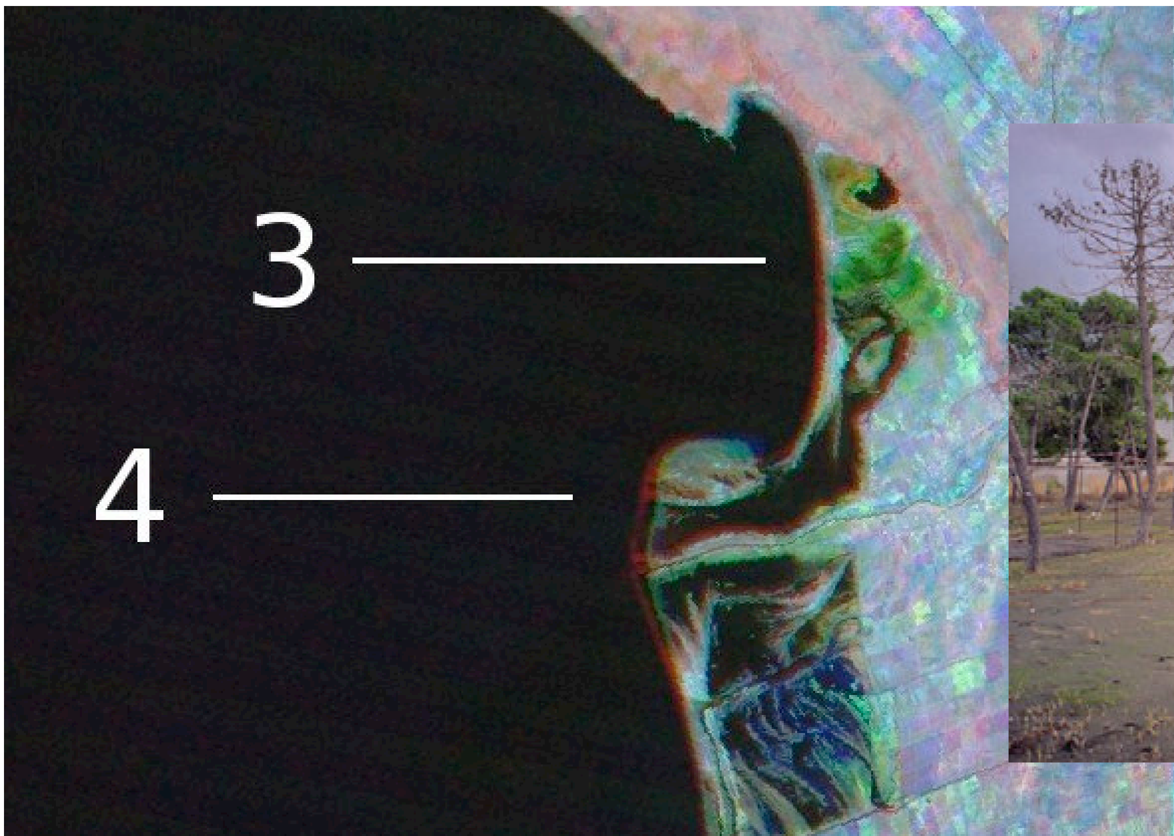
Buna River Delta & Velipoja

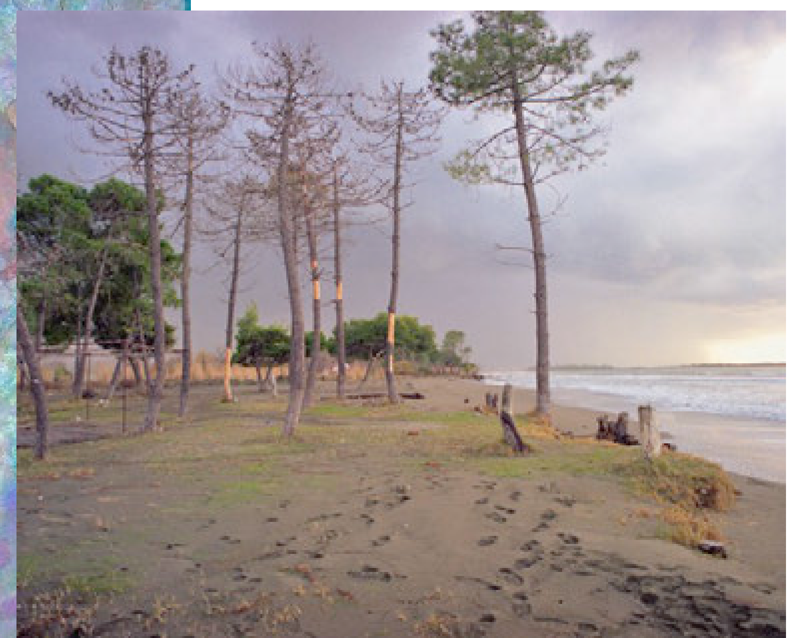
- Shift of sand from Delta east to Velipoja



Drini Bay & Shengjini

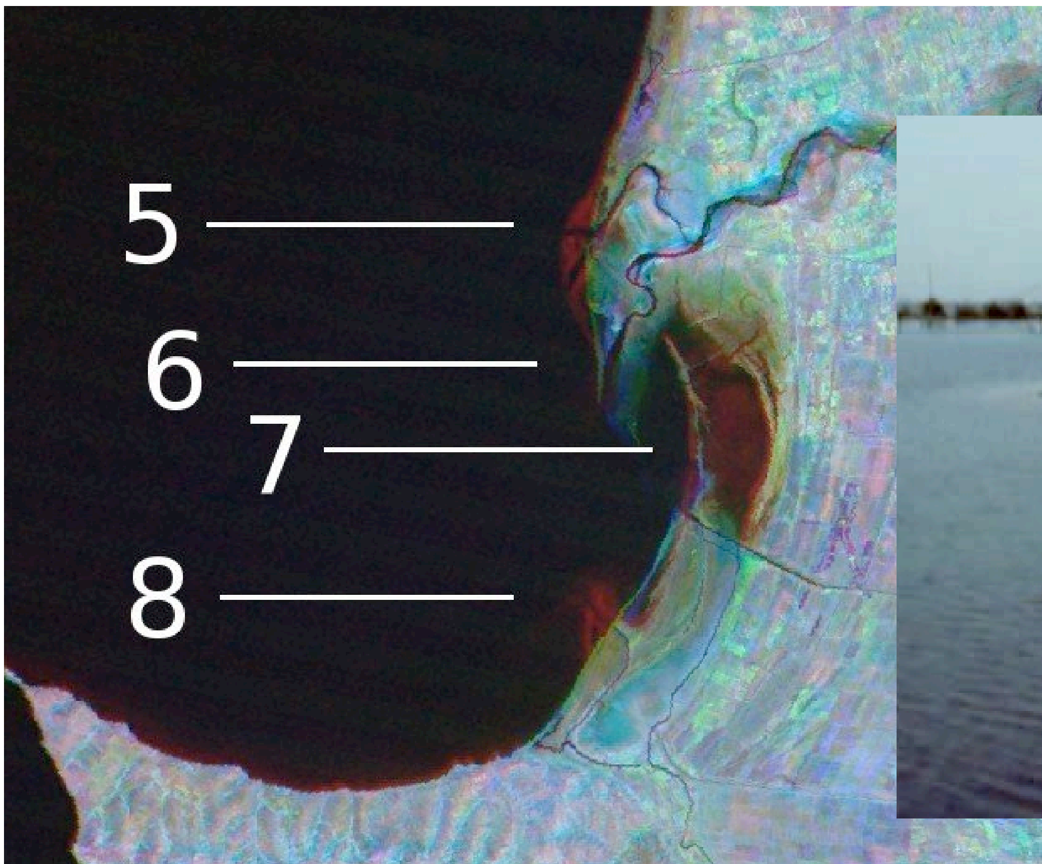
- Shift of dunes towards east
- Shore eroded / submersed





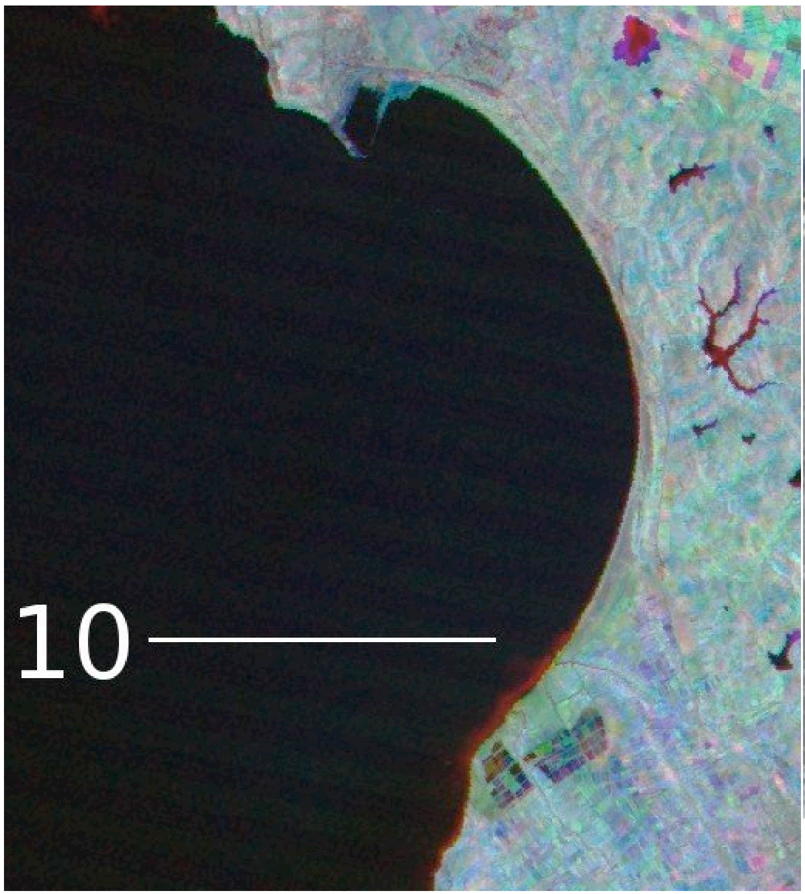
Disaster in Patoku

- Old beach and buildings destroyed
- Deltas shifted ! Land submersed ?



Durresi Bay

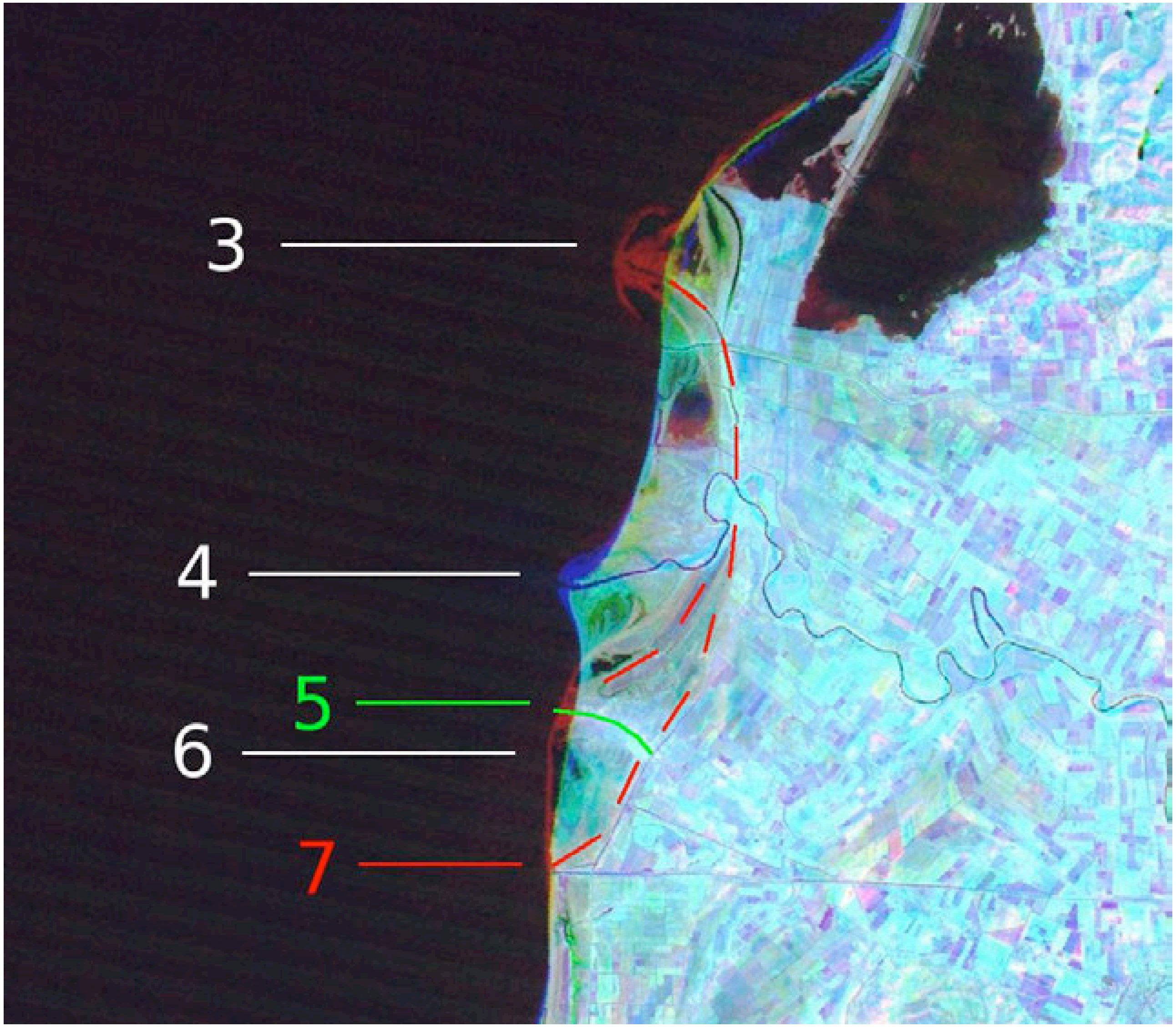
- Heavy human impact ...
- Duality erosion ~ accumulation (Qerreti)



Disaster in Semani

- Considerable loss of land
- Constructions covered by the sea
- Significant shift of rivers deltas
- Traces of old shorelines
- Two typical objects
  - Borehole basement
  - Water tower
- Land submersion / erosion / both ???

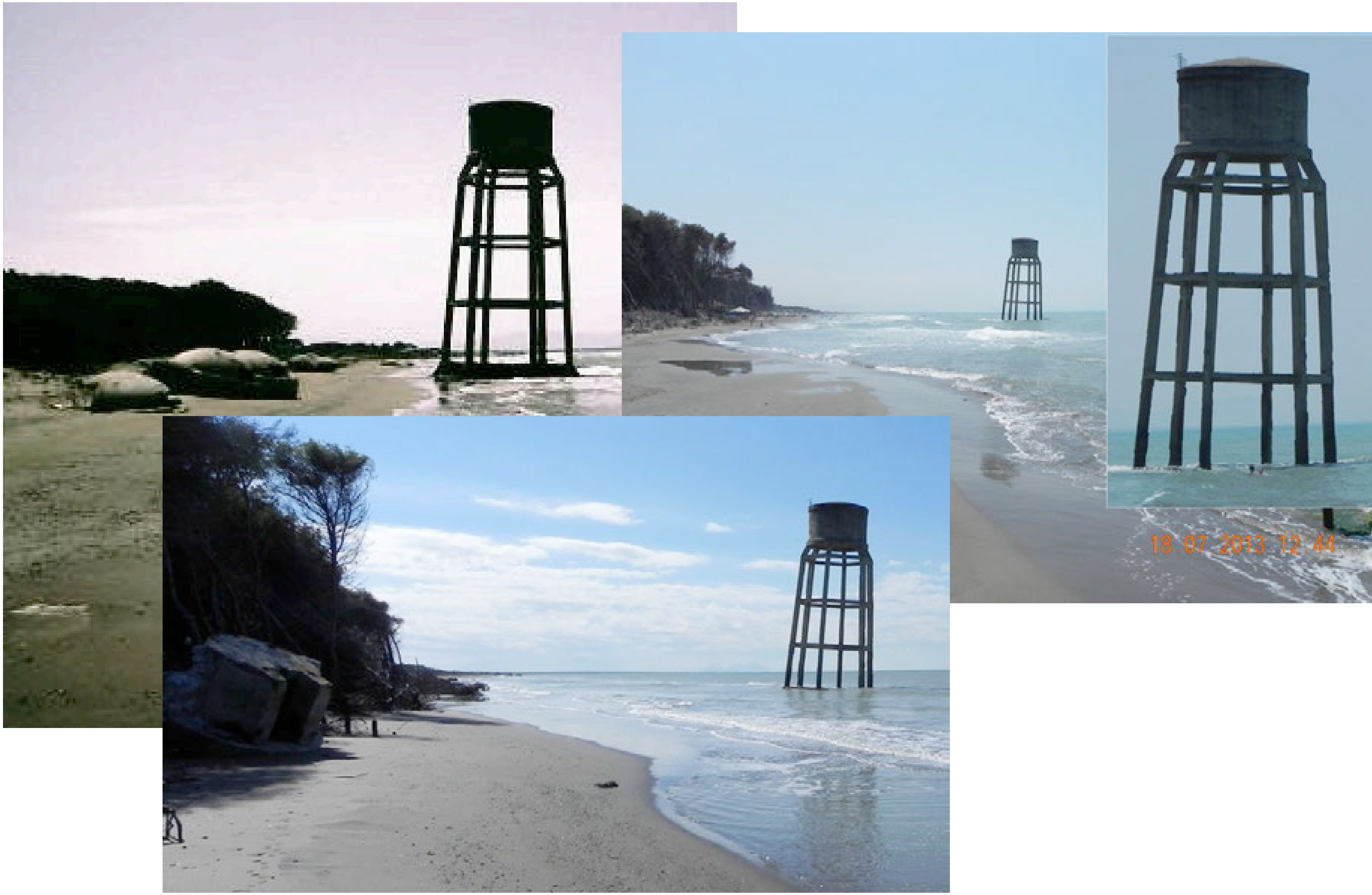
Semani shore from Landsat

- 

Borehole basement 2003 – 2013

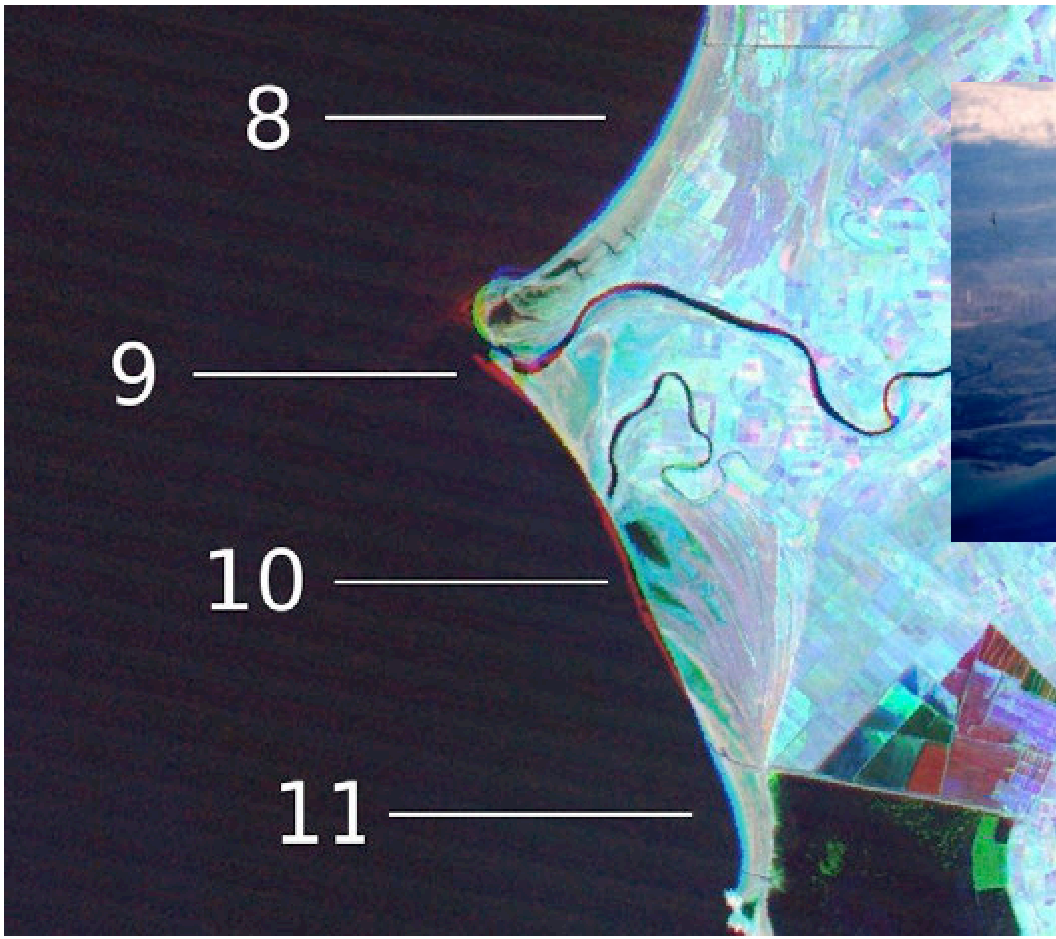
Erosion
or
Submersion
???

Water tower 2007 - 2013



Vjosa River Delta

- There are some changes ...



Actual Vjosa delta is eroded similar with Buna delta

Conclusions

- Landsat archive helped to investigate the whole length of Albanian Adriatic shoreline
- Very dynamic shoreline that interacts with human activities with serious impact
- Need for continuous monitoring and careful planning for human activities in shore areas
- Signs of land submersion
  - Need for future research and monitoring
  - Trying to use SAR interferometry ...

THANK YOU !

- Time for questions

20th **European Meeting of Environmental and Engineering Geophysics**
14-18 September 2014, Athens, Greece

IMPACT OF HYDROPOWER LAKE WATERS ON THE DESTABILIZATION OF SLOPES AND CAUSING LANDSLIDES TO ITS SHORES

Alfred FRASHERI

1. Introduction

Albania has numerous and biggest dams belonging to the hydroelectric power plant system. These dams are made of concrete and/or rock fill with central clay core. Drini River hydropower plant cascade, at the Northern Albania, is the most biggest. This cascade is composed by Fierza, (1978), Komani (1985) and Vau Dejës (1971) hydro power plant. Fierza Hydroelectric Power Plant at higher river flow, has an installed power of 500 MW. The volume of water in its artificial lake is 2.7 billion m^3 , and lake depth averagely 133 m. The dam has a length on head of 400 meters and height 167 meters. Difference between maximal and minimal levels of surface water in lake was varied over the years from some meters up to 30 or more meters, depending on the annual meteorological conditions. Komani Hydroelectro Power Plant at the middle river flow, has an installed power of 600 MW. The volume of water in its artificial lake is 430 million m^3 . The dam has a length on head of 400 meters and height of 133 meters. At the lower river flow is Vau Dejes Hydroelectric Power Plant, whixh has an installed power of 250 MW. The volume of water in its artificial lake is 560 million m^3 . The Qyersaqi has a length on head of 480 meters and a height of 47 meters.

The exploitation of hydrotechnical work over the last 27 to 41year has influenced the modification of their physical- mechanical properties and constructive structure, but also to the lake shore slopes and water reservoirs. There are observed active landslides in the lakeshores. The most biggest is landslide at Porava village, about 2,5 km from the Fierza dam, and Ragami landslide near of Ragami Dam in Vau Dejës. These landslises represent a great geological risk for hydropower plants, and Porava village. Walls of the houses are broken in Porava villages. During the exploitation period of averagely more than 25 years, the changes of the huge hydrotechnical works influenced the physical-mechanical properties in the shore area and caused a series of landslides.

Results of the complex geological-geophysical-geodesic investigations in above mentioned landslides, and impact of the lake water on slope's soil and rocks, are presented in the paper.

2. Results analyze

Hydrotechnical works in Albania are generally constructed in conditions of mountains rugged terrain and in geological formations in which the landsliding phenomena is often present. The landsliding phenomena develops in the bedrocks and the overlaid loose delluvion and elluvion. This phenomenon has been more evidently activated after the construction of hydrotechnical works.

The exploitation period of more than 25 years of such a huge hydrotechnical work has influenced to the physical-mechanical properties at various parts of this landslide.

- **2.2.1.1. The Porava Landslide**

A study conducted in the Fierza hydropower plant, constructed over the Drini River in Northern Albania, is a clear example of it. This hydropower plant was build in 1974 and has an installed capacity of 500 MW. The lake, created after the construction of the plant, has a water volume of 2.7 billion m^3. The hydropower plant consists of several complex hydrotechnical works. The main one is the dam with stones and a clay core, which has 165 m high and 500 m long. There are observed active landslides in the lakeshores of hydroelectric power plants, which represent a great geological risk at Porava village, about 2.5km from the dam (Fig. 2.2, 2.3, photo 2.1). Buildings have been destroyed in some villages and some people died in ruins. This phenomenon has been more evidently activated when hydrotechnical works started to be used. During the exploitation period of more than 25 years, the huge hydrotechnical works influenced the physical-mechanical properties in the shore area and caused a series of landslides. According to geological data, gathered during the design period, Porava landslide has a slipping mass of about 34 million m^3.

- Special attention has been paid, since the projection period of this study, to the big slides in the shores of the Fierza Lake, especially to the Porava one (Fig. 2.4-a). The studies have not only included the geological understanding of the shore's solidity but also the understanding of the landslides. They also include solidity-integrated calculations through the hydraulics patterns. For that, the body fall of the Porava landslide at different speeds (from 5-10 m/sec) was simulated. As calculating parameters were used the ones resulted from geological studies of that time.

Fig. 2.2. Drini River Basin

Ragami and Porava Landslides location (Scale 1:300 000)

Fig. 2.3 – a. Porava landslide area

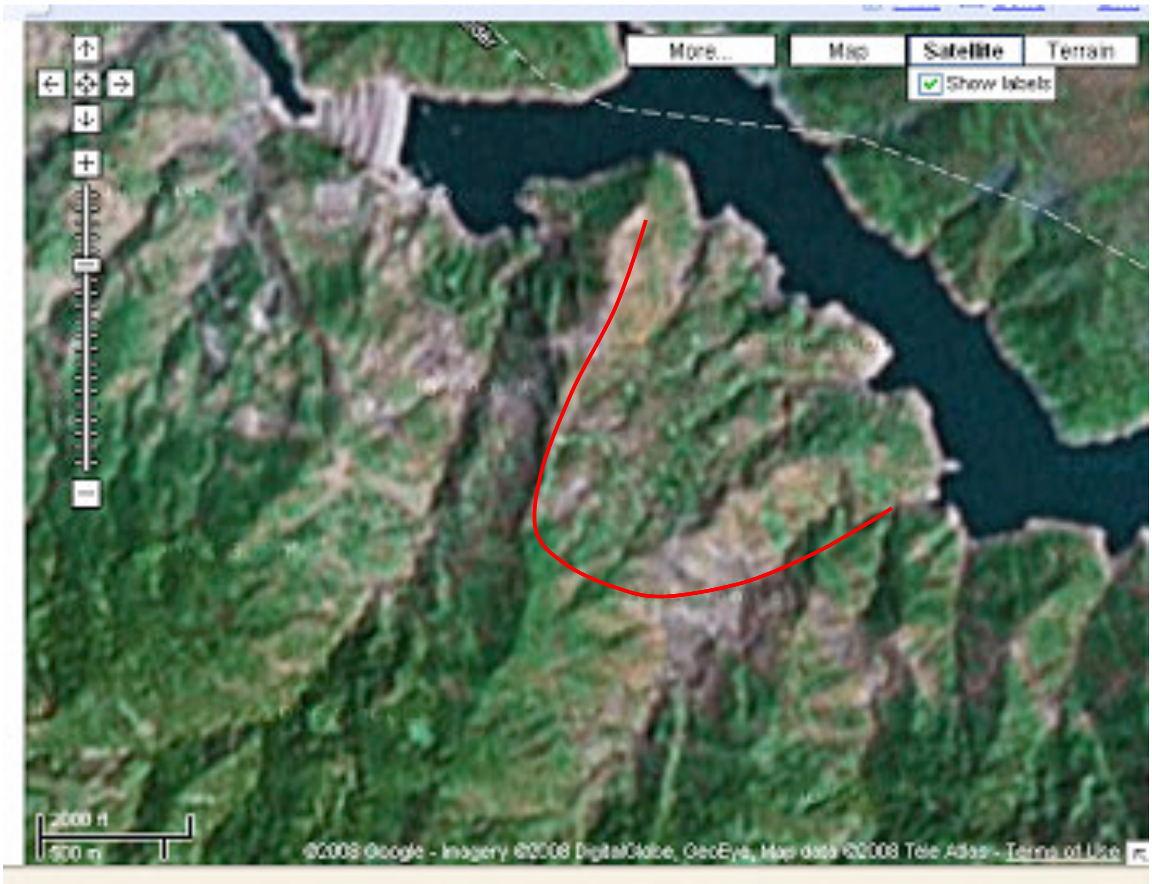
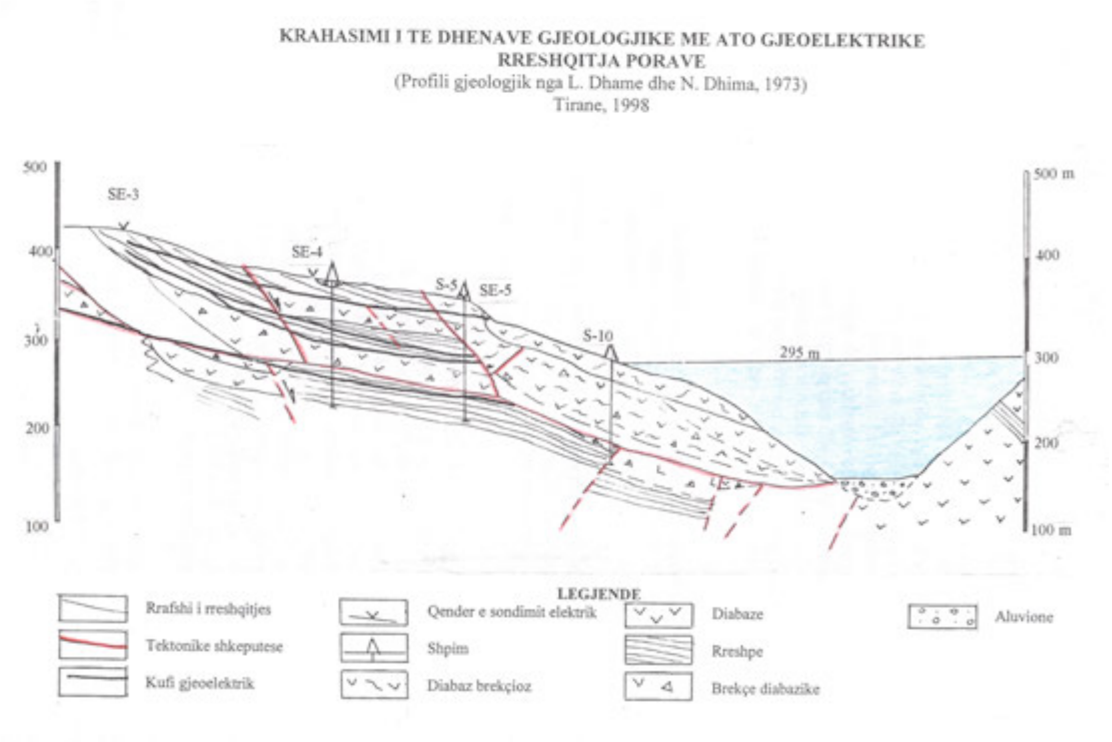
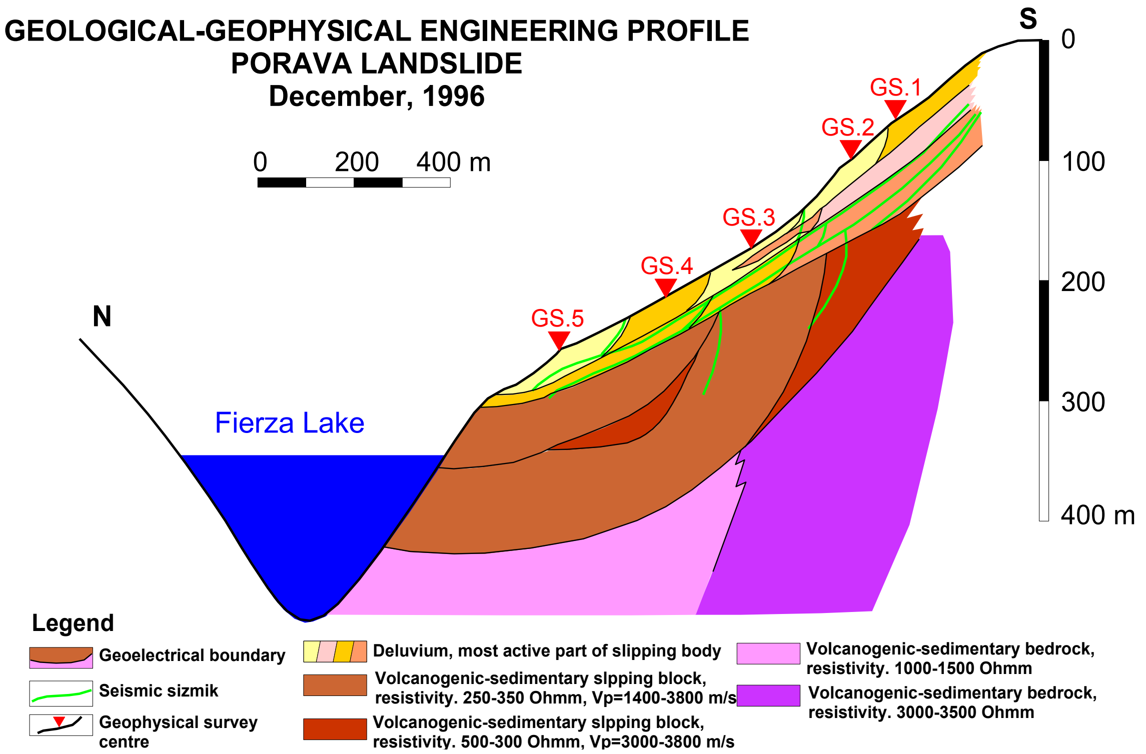


Fig. 2.3 – b. Porava Landslide area map (Scale 1:25000) and satellite view.

Photo 2.1. Cracks of the village houses walls

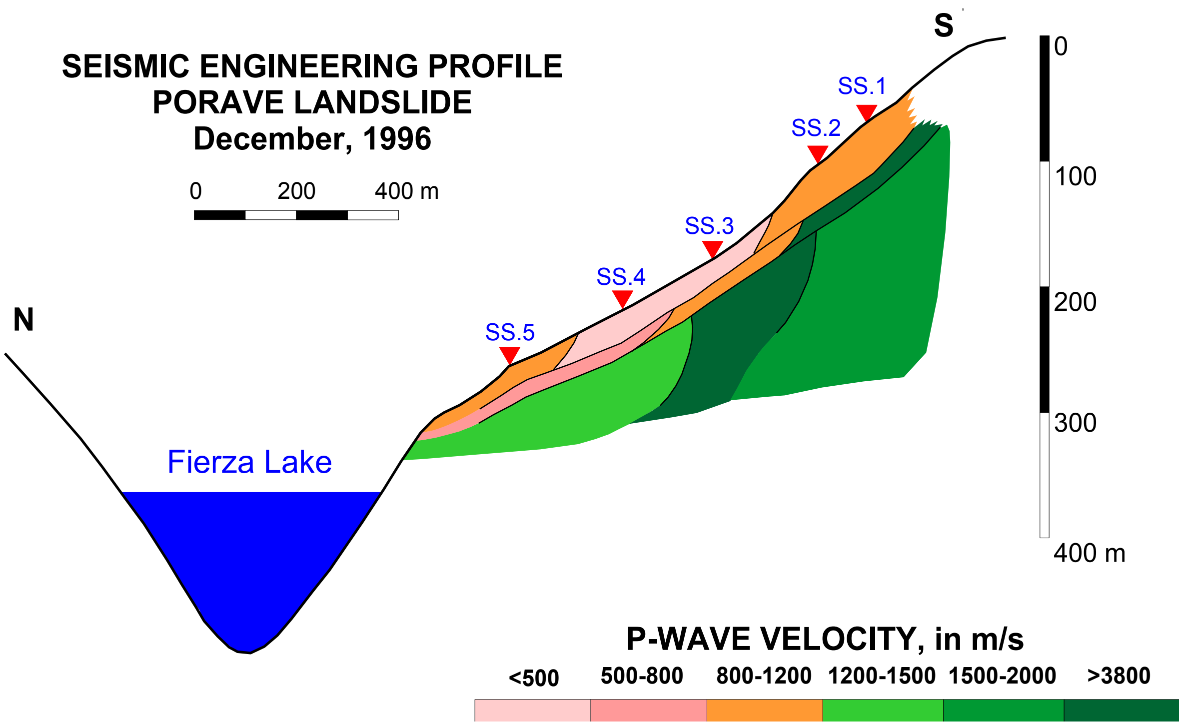


a)



b)

Fig. 2.4. Geological (1974) (a) and geophysical data (b) (1996) data comparison.



c)

Fig. 2.5. Seismic engineering profile, Porava Landslide (1996).

All those studies brought to the conclusion that the dike should be

raised 12 more meters over the one initially determined in the project, so that it would be more secure.

Today, based on the data generated from geophysical surveys, the geological knowledge about this zone and the visual study of the actual situation of the Porava landslide, it was realized the respective analysis of these integrated geophysical works.

In Fig. 2.4-b is presented the detailed geoelectrical - engineering section. This section was compiled based on the date of the vertical electrical soundings. In that can be noticed the presence of the very heterogeneous electrical medium in strike and depth. There are two categories of geoelectrical borders in the profile. These are the primary borders, connected with the separation of the main zones of the slipping body (with that of the deepest plains 140-160 m deep and with that of the most superficial plane 20 m deep). These slipping plains have very different geoelectrical characteristics, because they have different geological properties. The second category belongs to the secondary geoelectrical borders, which clearly express the changes and the heterogeneity that exists in these two slipping planes and in the environment under them.

First of all, in these geoelectrical markers is expressed the full configuration of the sliding structure in the rocks of the volcanogenic sedimentary section. As a result of the slipping phenomena, these rocks have low, up to medium specific electric resistivity values (200 - 100 Ohmm). While the rocks located under the whole massive slipping body have higher specific electric resistivity values (in the furthest sector of the profile in the lake side 3000 - 3800 Ohmm and 1200 - 1400 Ohm in the sector located near the artificial lake of the Fierza hydropower plant).

The most upper part of this slide's body, represented by the deluvial-eluvial deposits, is very active today and has very law specific electric resistivity values (120 - 500 Ohmm). Houses and other objects of the Porava district are constantly damaged by this activity.

The apparent geoelectrical heterogeneity in the strike of the profile, expresses the block kind composition that has in general this slide and it also gives an envision of the development of this slide in time.

In fig. 2.5 is presented the seismic-engineering section in the same profile with the geoelectrical one. In this figure can be distinguished very well the upper part of the slipping body (the zone 25 m deep). In this section are very well distinguished the two seismic parameters (in the speed of the longitudinal and cross waves). The deluvial deposits have been fixed with Vp = 400 - 1200 m/s and Vs = 150 - 450 m/s values, while the eluvial deposits and the volcanic rocks of the most upper part, located over the slipped plane have Vp = 800 - 3880 m/s and Vs = 350 - 800 m/s values. The volcanic deposits located below the first slipping plain have been fixed with Vp = 1400 - 3800 m/s and Vs = 600 - 1500 m/s.

Based on the seismic parameters, the evaluation of the physical - mechanical characteristics of the rocks of this sliding body was carried out in strike and depth. In this seismic section and in the geoelectrical one, can be seen the block kind nature of the upper part of the slipping body and also of the lower part of this body in the basement volcanic rocks.

By studying the natural seismic-acoustic activity, different recordings can be noticed in all the surveying zones. This shows that the sliding activity is different for different parts of the slipping body. The most dynamic zones of this sliding massif are located in places where the micro - movements have maximum intensity values. The Porava village is located in one of these zones. Because of this activity, many houses, and the soil is damaged and slopes have moved about 2 - 4 m within a 2 - 3 years period of time (1994 - 1996)(Photo 2.1).

In the detailed and integrated geophysical - engineering section, can be noticed a concordance between the electrical sounding results and the seismic surveying ones, used for studying this slide. (Fig. 2.4).

Also, in this section can be determined sliding plains, their nature, situation and the content of the two parts of the slipping body. The most upper part is made of deluvial-eluvial deposits and reaches up to 20 m deep, above the first most dynamic plain of this zone. Under this lays the volcanic rock massif, located over the deeper plane of the Porava landslide (100- 160 m). This plain is determined and separates the block like sliding body from the volcanic rocks, which have not been touched by this sliding activity.

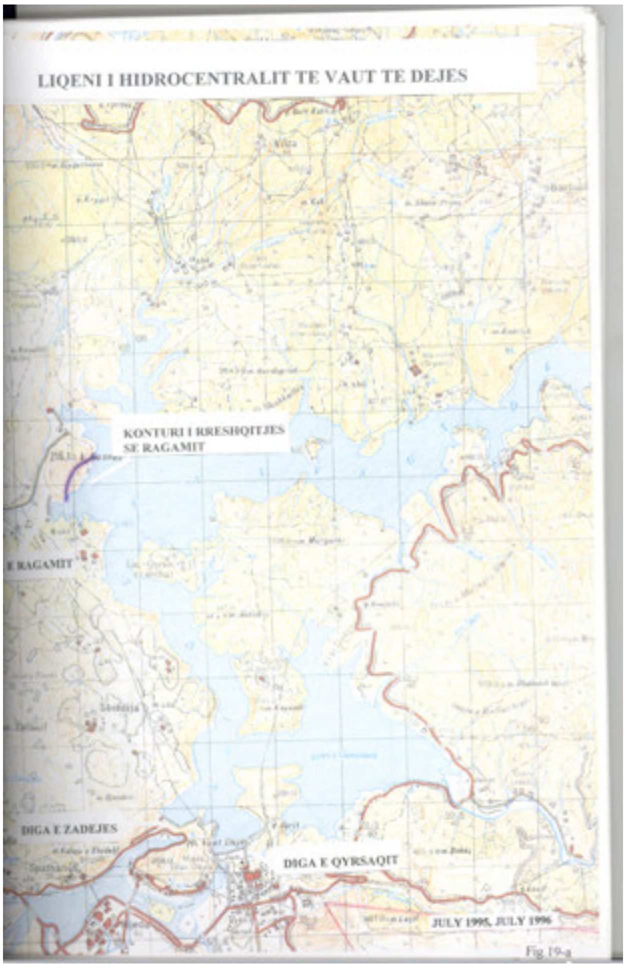
Based on the results of this integrated geophysical-engineering and geotechnical study result:

1. There could not happened an immediate fall at any speed of the Porava slipping body.
2. Even in cases of powerful earthquakes, the slipping body mass can not fall as a whole, because it is made of broken up block masses. It can fall parts by parts or in fragments. Natural or inductive earthquakes of normal intensity, which happen often in this region, till now have not caused massive detachments of the slipping body.

2.2.1.2. The Ragami Lanslide

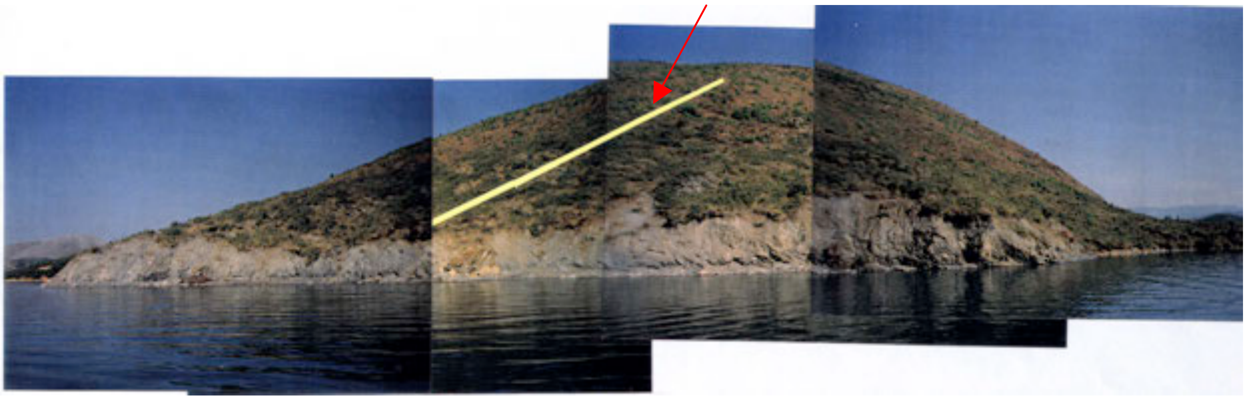
The typical landslide was developed at lakeshore of the Vau Dejes Lake of Hydropower Plant in Northwestern Albania (Fig. 2.6). It is developed in the ophiolitic formation represented by serpentinized rocks. The slipping body represents a big mass of serpentinite, which is eolated, destroyed and covered by a thin layer of deluvium. According to the geological survey in 1992, the landslide did not exist. Landslide has been significantly developed during the last ten years (Fig. 2.7). The yearly movements of water level at Vau Dejes Lake caused a big landslide at eolated, weathered and destroyed serpentine rocks. Slipping body increased in the extent and in the volume substantially during this period. The front part of the slipping body is located along the shores of the lake. This part has the shape of a scarp about 2 -3 m high, and represents a destroyed, schistose serpentinite, partly in a form of mylonite (Photo 2.2).

In fig. 2.8 –a, b are presented the integrated geophysical - engineering sections of the slipping body. Two main sliding plains separate this body. These plains are broken up. The first plain is at depths of 5 - 7 m, while the second one reaches up to 22 m. The lowest part of the second plain touches the lake, under the water level. In this way, the sliding body has a block like nature. The physical - mechanical properties of the rock massif of the slipping body are lower than those of the basement rocks, not touched by the sliding phenomena. The micro movements in the slipping body are very intensive and have a wide frequency band, while outside the body there is no such activity (Fig. 2.9).


LIQENI I HIDROCENTRALIT TE VAUT TE DEJES
KONTURI I RRESHQITJES SE RAGAMIT
E RAGAMIT
DIGA E ZADEJES
DIGA E QYRSAQIT
JULY 1995, JULY 1996
Fig 19-a


Ragami Landslide
Image © 2008 DigitalGlobe
Image © 2008 TerraMetrics
©2007 Google™

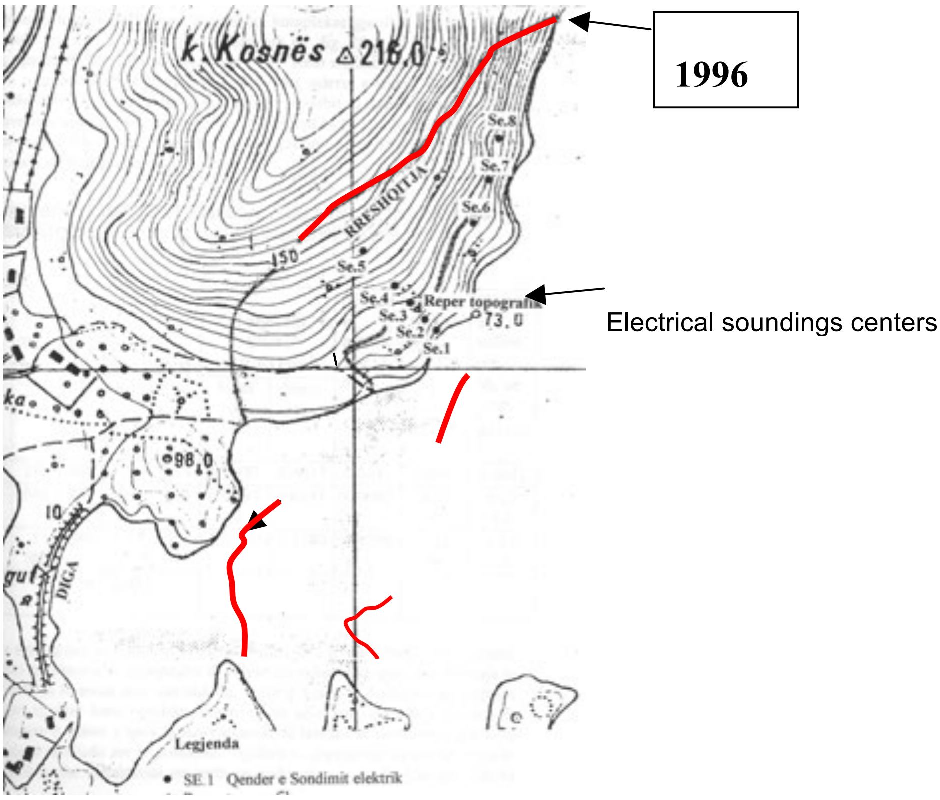
Fig. 2. 6. Vau Dejes area and Ragami Landslide, Geophysical survey line

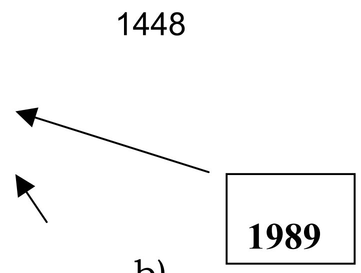


a)

b)

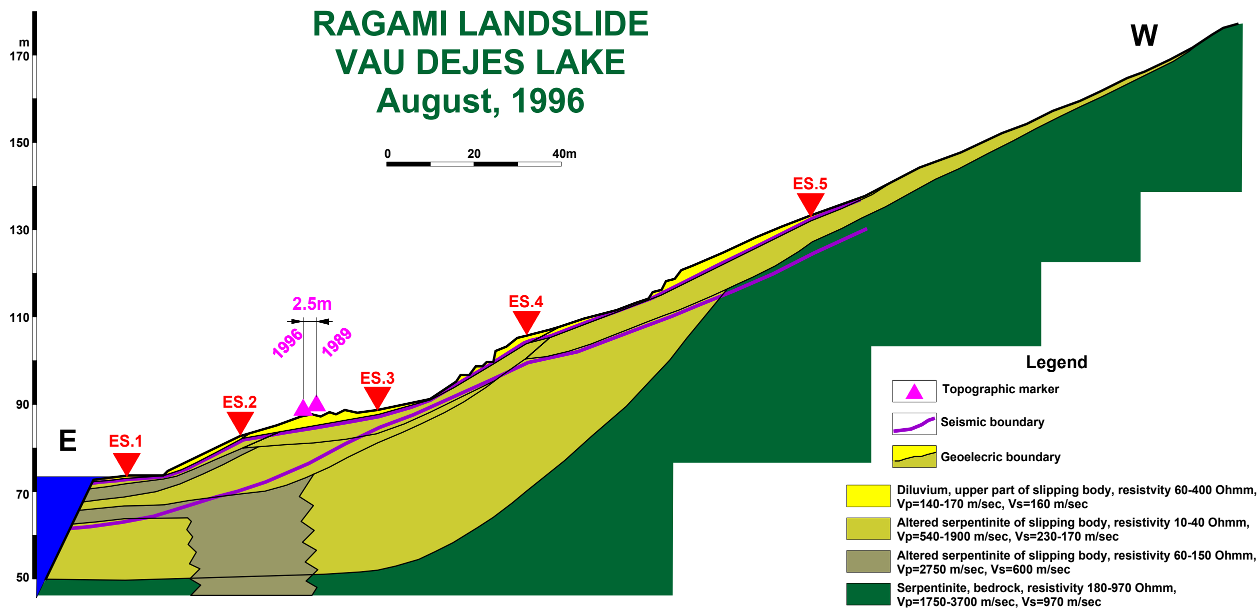
Photo 2.2. Ragami landslide area (a), and font of the sliding body, represented by mylonite serpentinites (b)



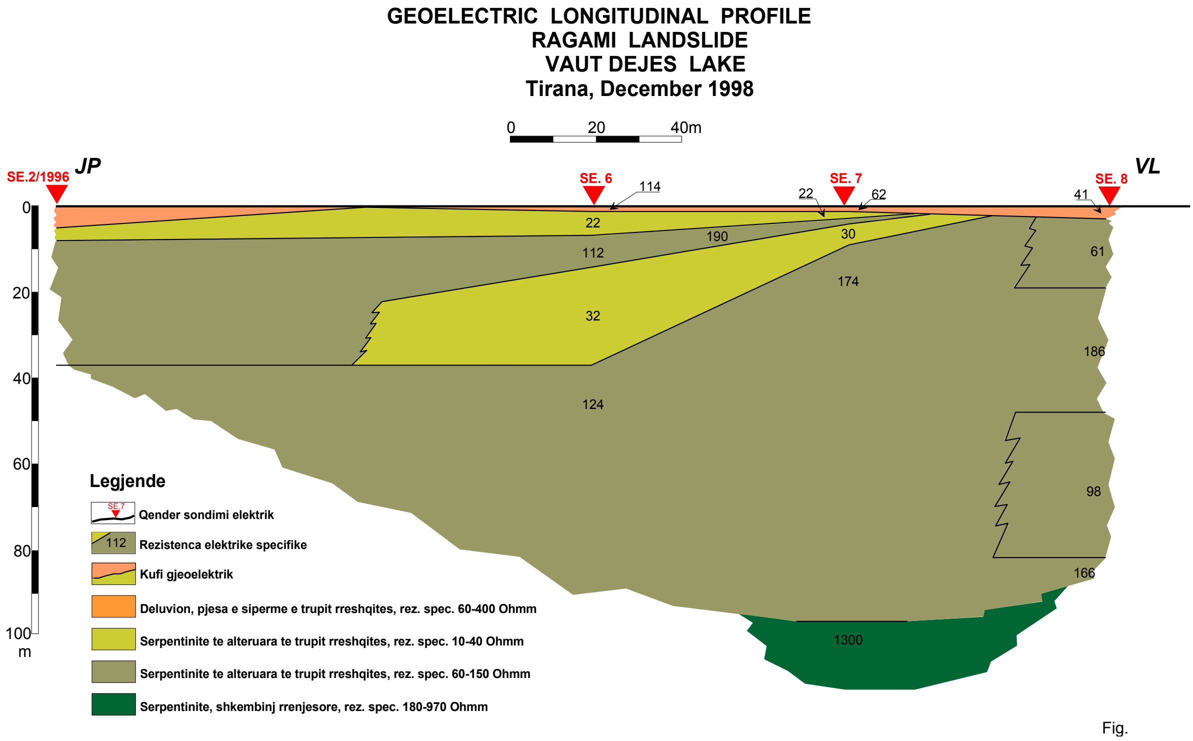


b)

Fig. 2.7. Topographical sketch of Ragami Landslide area (1989; 1996) Landslide body contours, respectively (a), and Satellite view (b).



Transversal profile



Longitudinal profile

Fig. 2-8. Engineering integrated geophysical section of the Ragami landslide.

Three failures in different superficial levels can be observed in this landslide:

- The first one 35 - 45 m from the shore, with a horizontal dislocation of about 2 m.
- The second one about 70 - 90 m from the shore, with a vertical jump of about 2 m.
- The third one about 115 - 130 m from the shore. This is the newest level and has the lowest amplitude.

The physical-mechanical properties of the slipping body are lower than those of the basement rocks, not touched by the sliding phenomena.

Physical-mechanical properties of rocks in the area of Ragami Landslide are presented in Tables 2.1 and 2.2.

Tab. 2.1

PHYSICAL PROPERTIES IN LANDSLIDE'S AREA

Layer Number	Thick-ness, in meters	Resistivity in Ohmm	Density, in g/cm^3	Wave Velocity, in m/sec		Lithology
				Vp	Vs	
SLIPPING BODY						
1	0.7	76.4	1.34	210	160	**Deluvium**
2	4.0	29.5	1.61	540	230	Breaking serpentinite
3	6.5	46.5	2.45	3700	680	Water-bearing serpenti-nite,
4	17.4			1500		Breaking serpenti-nite
BED ROCKS						
		485	2.56	3500	1920	Serpentinite

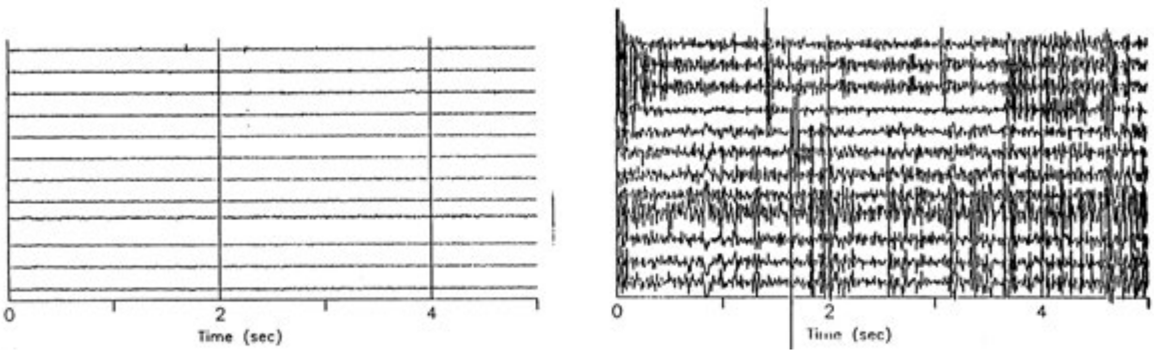
Tab. 4.2

. MECHANICAL PROPERTIES IN LANDSLIDE'S AREA

Layer Num-ber	Poisson's Ratio	Dynamic Modulus of Elasticity, E_d^s in $*10^5$ kg/cm^2	Rigidity Modulus G, in $*10^5$ kg/cm^2	Volume Compre-ssion, σ,	**Rock state**

				in $*10^5$ kg/cm^2	
SLIPPING BODY					
1	0.35	0.00370	0.00140	0.00420	soft rocks
2	0.39	0.02413	0.00868	0.03630	Destroyed, shattered rocks
3	0.48	0.56586	0.19167	3.26503	***Cleavages and fissured rocks***
4		0.26325	0.09608		Destroyed, shattered rocks
BED ROCKS					
	0.29	2.46271	0.96199	1.91408	**Compact rocks**

As documented in Tables 2.1 and 2.2, four layers with different physical-mechanical properties create the slipping body. First layer represents the deluvial cover. Layers 2 and 4 are represented by destroyed-shattered serpentinite. The third layer in between is characterized by low electrical resistivity and low shear waves velocity. It corresponds to the water saturated cleavages and fissures in the serpentinite.
The dynamics of slope movement is also reflected in the natural seismic-acoustic activity. The micro-movements in the slipping body are very intensive and have a wide frequency band. No movement activity is observed outside the slipping body (Fig. 2.9).



Outside of slipping body Inside of slipping body

Fig. 2.9. Natural seismic-acoustic activity in the Ragami landslide area

After the analyze of geophysical investigations in Ragami landslide, have been concluded:

1. Thick and high volume slipping bodies represent the Ragami active landslide in the shore area of the Vau Dejes Lake.
2. The extent of the landslide and the position of sliding plains were precisely fixed using the integrated geophysical survey.
3. The block-like character of the sliding bodies brings to the conclusion that the block of these bodies can not fall down immediately in any kind of velocity.

4. Conclusions

1. Geophysical-engineering studies have a triple character:

a) The soil of the landslide area investigation,

b) Evaluation of in-situ physical-mechanical properties of soils and rocks, and

c) In-situ monitoring of landslide phenomena dynamics.

2. Based on the above analyses can be reached the following conclusions:
In the integrated geophysical-geological profiles are fixed studied landslides bodies. In these profiles were also clearly fixed the sliding plains.
In general, even though the geological conditions in which these slides have been developed are different, the plains have regular configuration, with maximum deepness in the center of the profile. The extent of the landslide and the position of sliding plains were precisely fixed using the integrated geophysical survey.

- The slipping body, very often, is made of several slipping plains of block like character.
- Especially active today, are the slipping plains located 15 - 20 m deep. The slipping body over this plain is mainly made of deluvial - eluvial sediments, or rocky masses with very weak physical - mechanical characteristics. Their dynamic is causing more damages every day to the houses of the Porava village.

- The block like nature of the sliding bodies brings to the conclusion that in general these bodies can not fall immediately as a whole, in any kind of velocity. Only in particular cases, like in Banja, the fall occurs immediately.
- The structure of the slipping body and its dynamic stands in the foundation of the patterning on the landslide development. Besides the others, the height of the dam is directly defined from this pattern. Accepting the slipping body as a unique mass, has sent to the over heightening of the dam and greater expenses.
- Porava landslide has a slipping mass of about 34 million m^3.

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monitoring using geophysical data. A Monograph, Academy of Sciences of Albania.

Frashëri A., 2011. Investigation and monitoring of slope stability and landslides. (In Albanian). Faculty of Geology and Mining, Polytechnic University of Tirana.

20th **European Meeting of Environmental and Engineering Geophysics**
14-18 September 2014, Athens, Greece

IMPACT OF HYDROPOWER PLANT WATERS ON THE DESTABILIZATION OF SHORES AND CAUSING LANDSLIDE TO ITS SHORES

Alfred FRASHERI

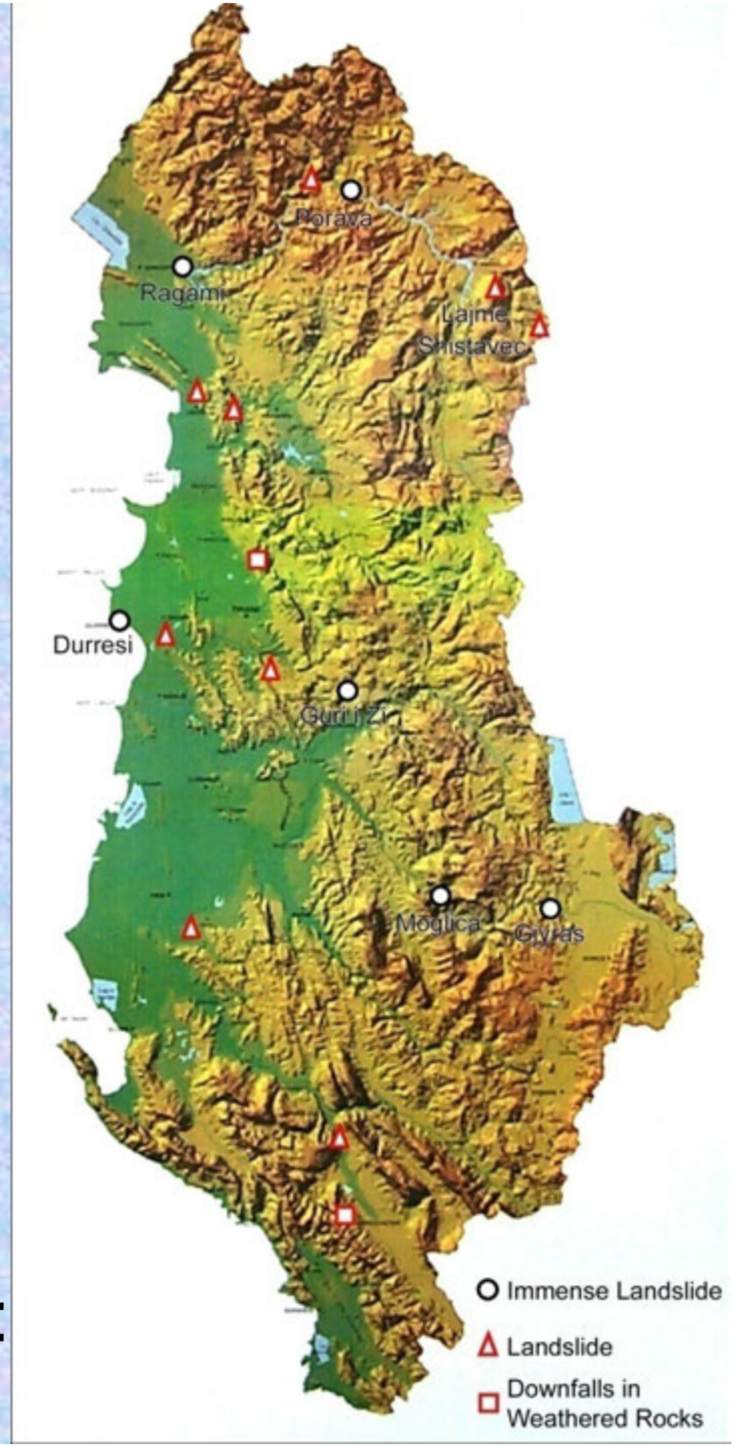
- *Faculty of Geology and Mining, Polytechnic University of Tirana, Albania*

- Tirana, 2014

1. Introduction

- Albania represents a mountainous country and Albanides are represented geological structures with possibilities of instable slopes and landslide development .

- Based on the geological formations and landslide body mass, can be present following landslide classification in Albania:



- Instable slopes and intensive landslides developed in weathered bedrocks and in overburden bed at the lakeshores of hydropower plants.

  Instable slopes and intensive landslides developed in Oligocene flysch formation.

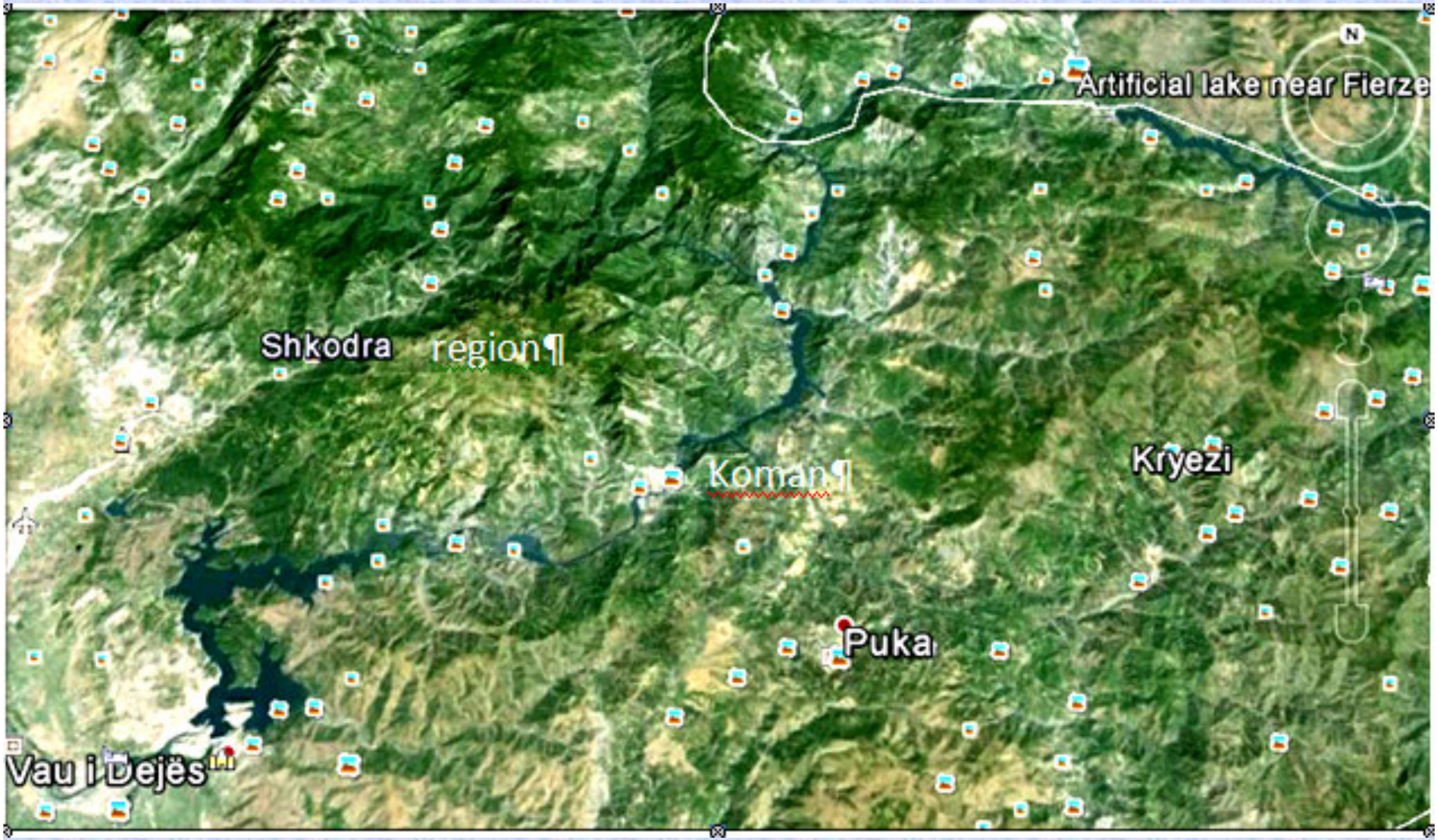
- Instable slopes and landslides developed in Neogene's molasses formations.

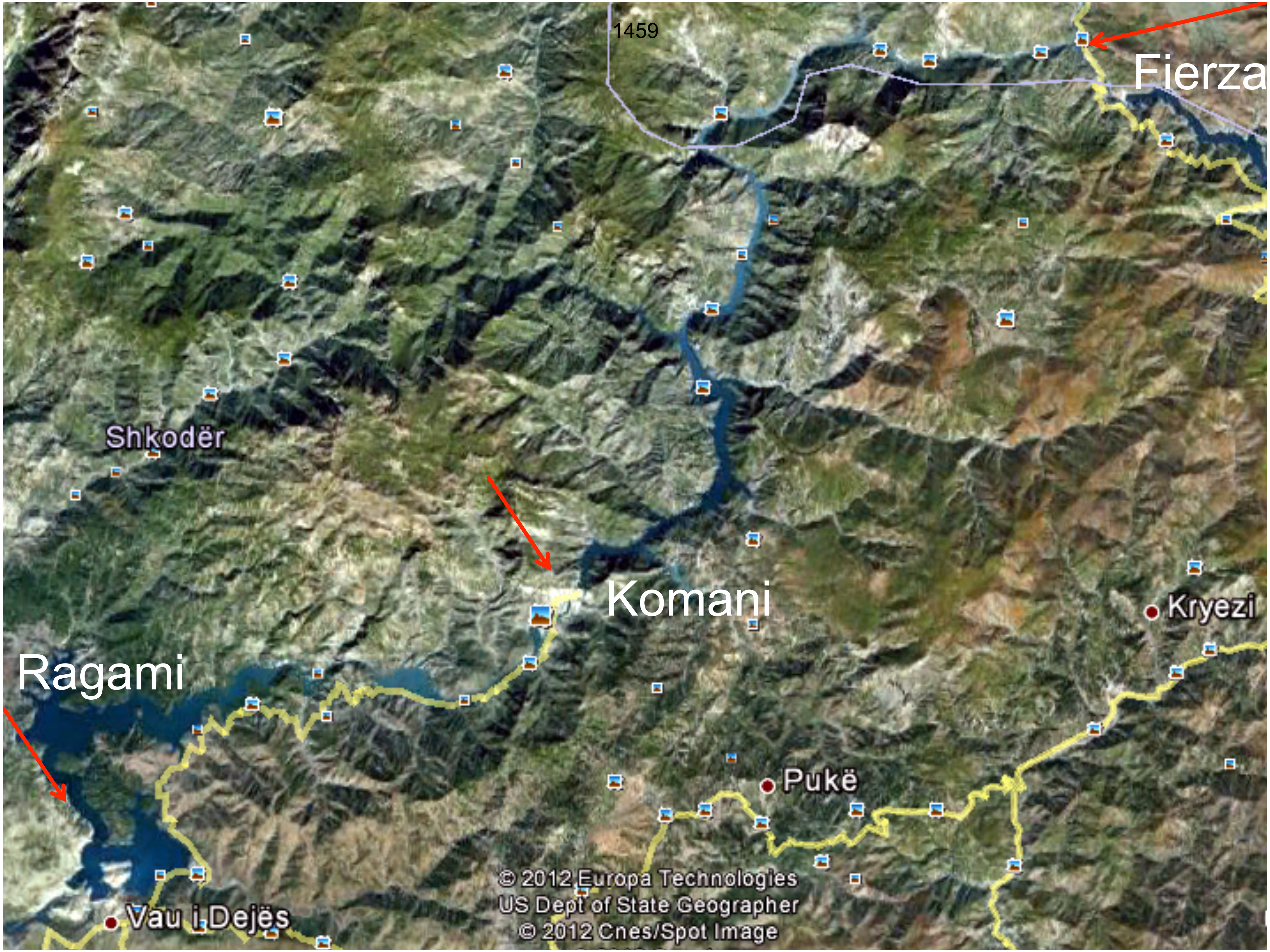
- Landslides developed in loose Quaternary deposits.

- Downfalls in the weathered rocks

- Albania has numerous and biggest dams belonging to the hydroelectric power plant system. These dams are made of concrete and/or rock fill with central clay core. Drini River hydropower plant cascade, at the Northern Albania, is the most biggest. This cascade is composed by Fierza, (1978), Komani (1985) and Vau Dejës (1971) hydro power plant. Fierza Hydroelectric Power Plant at higher river flow, has an installed power of 500 MW.
- The **volume of water** in its artificial lake is 2.7 billion m^3 and **lake depth** averagely 133 m. The dam has a **length on head** of 400 meters and height 167 meters.

DRINI RIVER BASSIN
RAGAMI AND PORAVA LANDSLIDES




1459
Fierza
Shkodër
Komani
Kryezi
Ragami
Pukë
Vau i Dejës
© 2012 Europa Technologies
US Dept of State Geographer
© 2012 Cnes/Spot Image

PORAVA HYDROPOWER PLANT
DRINI BASSIN

SATELLITE VIEV OF PORAVA LANDSLIDES

- **Difference between maximal and minimal levels** of surface water in lake was varied over the years from some meters up to 30 or more meters, depending on the annual meteorological conditions.

The exploitation of hydrotechnical work over the last 27 to 41 years has influenced the modification of their physical- mechanical properties and constructive structure, but also to the lake shore slopes and water reservoirs.

There are observed active **landslides** in the lakeshores. The most biggest is landslide at Porava village, about 2,5 km from the Fierza dam, and Ragami landslide near of Ragami Dam in Vau Dejës. These landslises represent a great geological risk for hydropower plants, and Porava village. Walls of the houses are broken in Porava villages.

PORAVA LANDSLIDE

- In the paper are presented results of the complex geological-geophysical-geodesic investigations in landslides in Albania, and impact of the lake’s water on slope’s soil and bedrocks.

– INTEGRATED GEOLOGICAL-GEOPHYSICAL IN-SITU INVESTIGATION FOR LANDSLIDE PROGNOSIS,

Study and monitoring.

- In-situ investigations and monitoring for investigation for landslide prognosis, study and monitoring were carried out by integrated engineering geology-geophysics methods:
- Geological Mapping
- Geomorphological Mapping
- Hydrogeological Mapping
- Engineering Geological Mapping

Geophysical Mapping, in-situ investigation and monitoring

Gravity micro survey

Magnetic micro survey

High Frequencies Seismic Tomography and profiling.

Geoelectric Tomography, electric soundings and profiling, etc.

Electrical, radiometric, sonic etc. well logging

Laboratory analysis and determinations
Geodesic observations.

In-situ geophysical investigation and monitoring are programmed to perform in three phases:

1. Surface integrated geological-geophysical survey and installation of geodesic markers.

2. Drilling of shallow boreholes, cross-hole seismic survey and well logging.

3. Periodical geophysical surveys and geodesic observations in boreholes and on the ground surface.

Consequently, geophysical-engineering studies have a complex character:

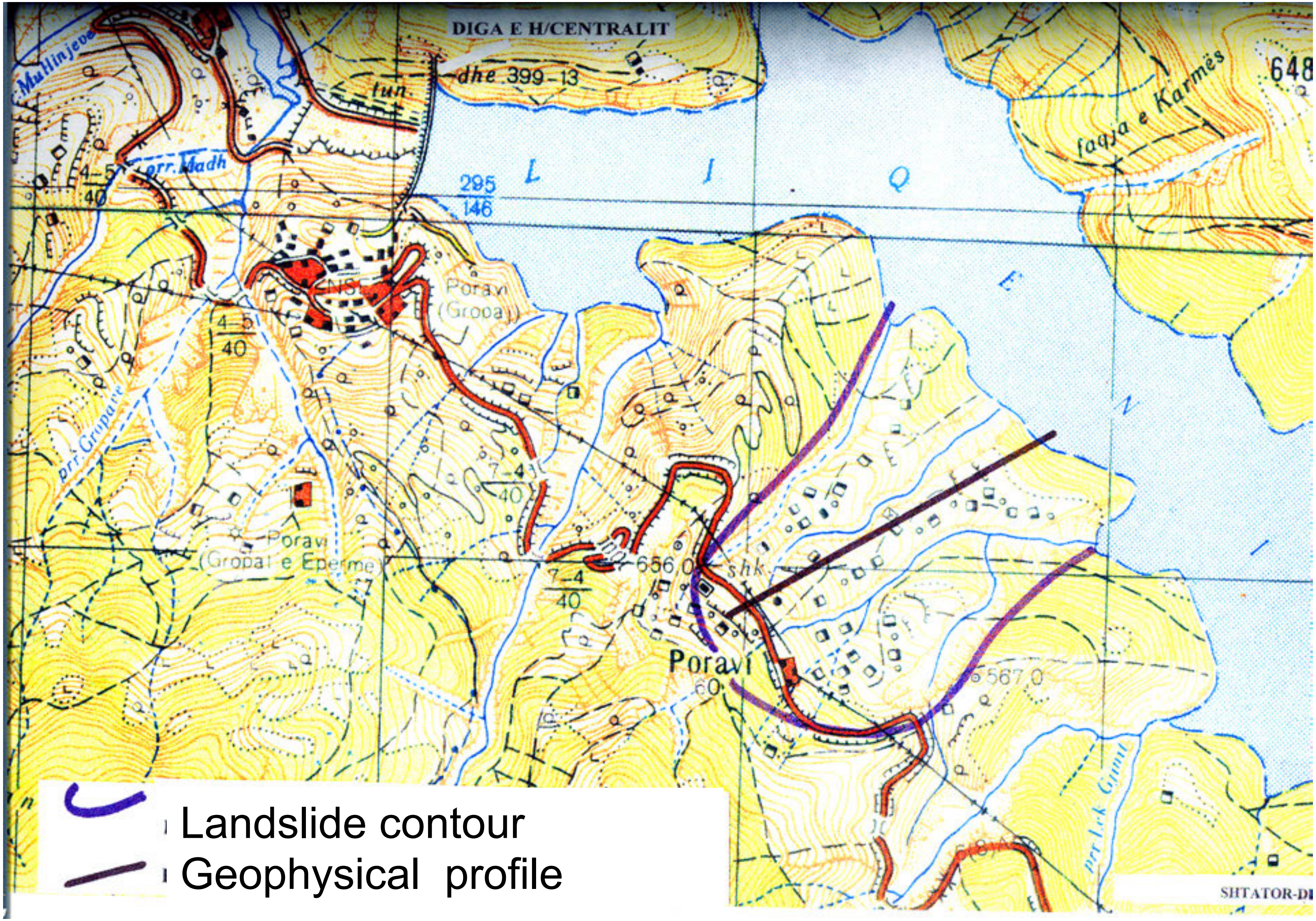
- To prognoses slope instability and landslide development possibility in the future,

- To study the landslide body structure and soil of the landslide area,

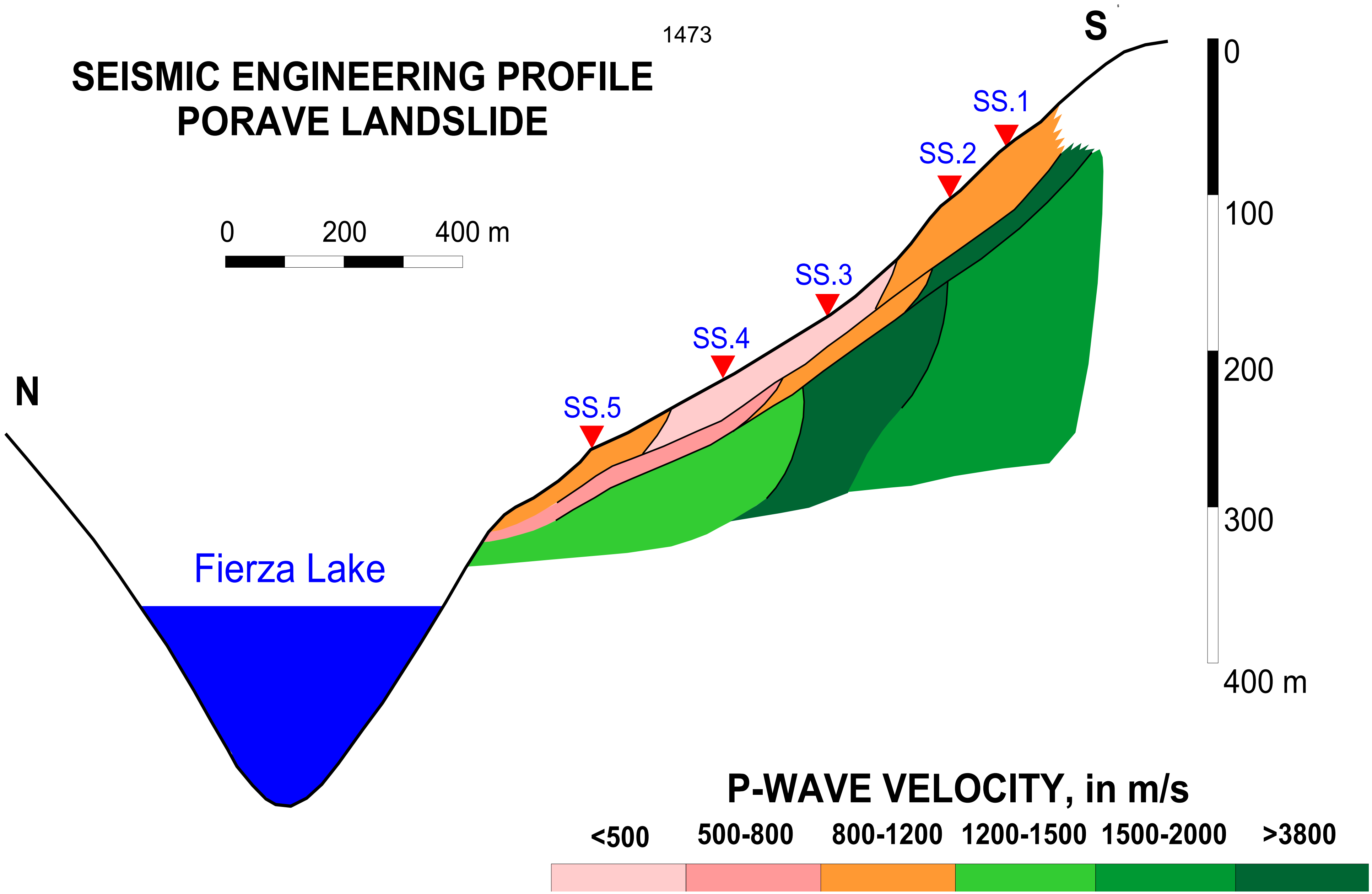
- Evaluation of in-situ physical-mechanical properties of soils and rocks and

- In-situ monitoring of landslide phenomena.

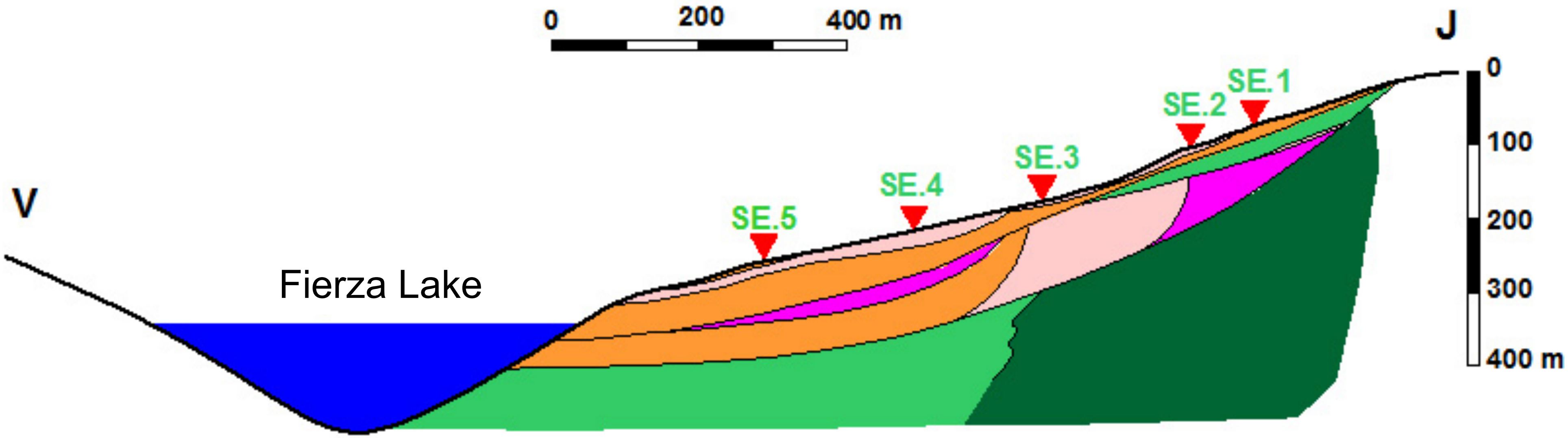
PORAVA LANDSLIDE PLANIMETRY



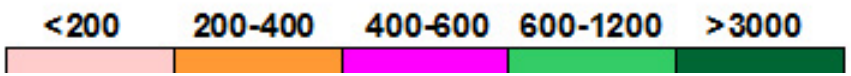
LOW FIERZA WATER LEVEL, SEPTEMBER 2013

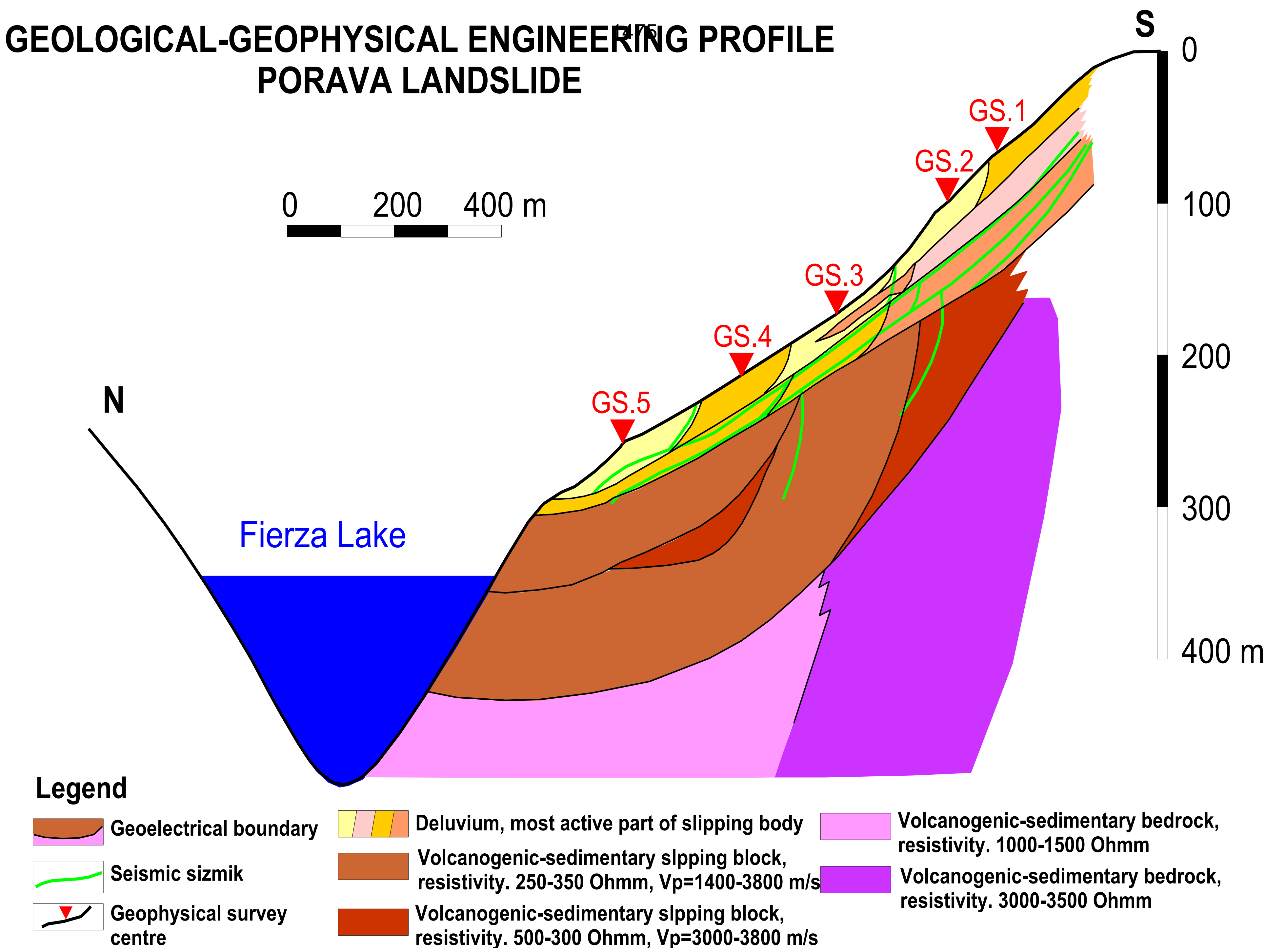

SEISMIC ENGINEERING PROFILE
PORAVE LANDSLIDE
0
200
400 m
N
S
Fierza Lake
SS.1
SS.2
SS.3
SS.4
SS.5
0
100
200
300
400 m
P-WAVE VELOCITY, in m/s
<500
500-800
800-1200
1200-1500
1500-2000
>3800

GEOELECTRICAL ENGINEERING PROFILE
PORAVA LANDSLIDE



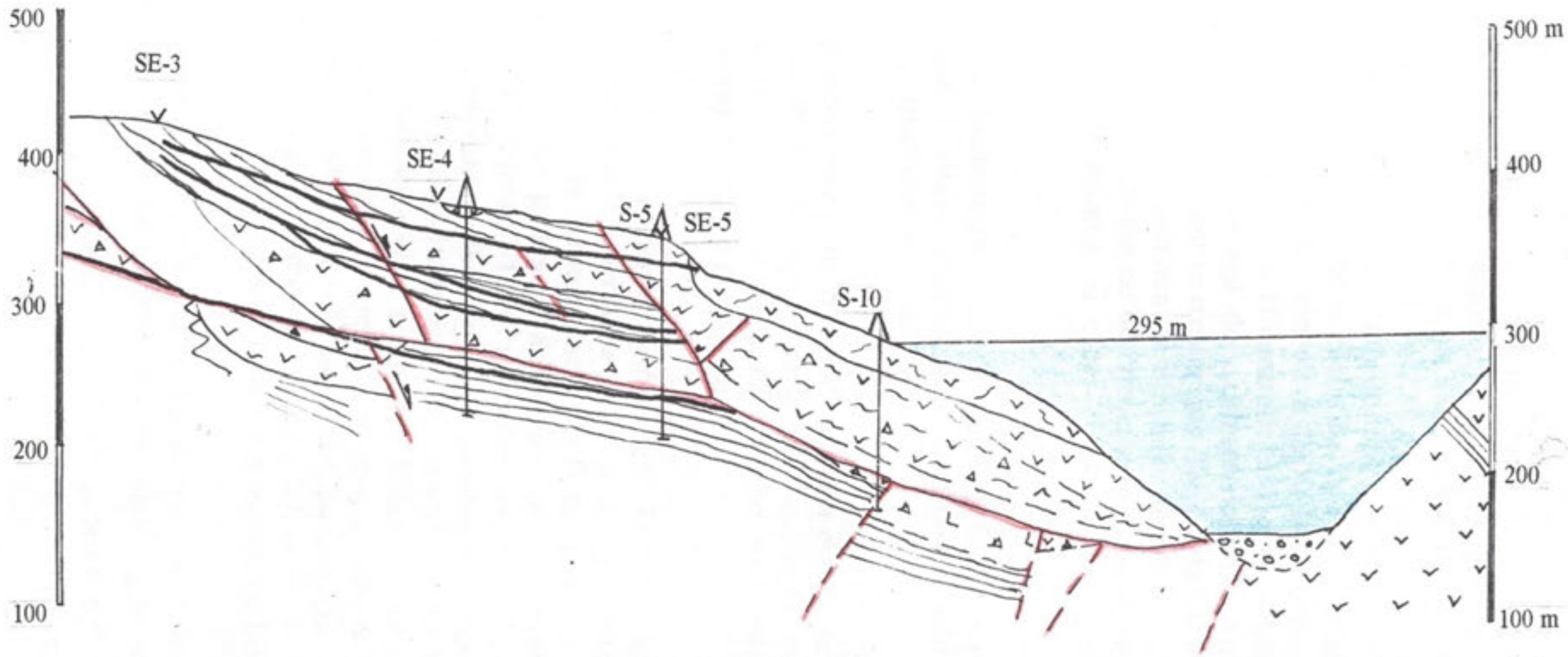
Eletric. Specific Resistivity, in Ohmm




GEOLOGICAL-GEOPHYSICAL ENGINEERING PROFILE
PORAVA LANDSLIDE
0 200 400 m
N
S
0
100
200
300
400 m
GS.1
GS.2
GS.3
GS.4
GS.5
Fierza Lake
Legend
Geoelectrical boundary
Seismic sizmik
Geophysical survey centre
Deluvium, most active part of slipping body
Volcanogenic-sedimentary slpping block, resistivity. 250-350 Ohmm, Vp=1400-3800 m/s
Volcanogenic-sedimentary slpping block, resistivity. 500-300 Ohmm, Vp=3000-3800 m/s
Volcanogenic-sedimentary bedrock, resistivity. 1000-1500 Ohmm
Volcanogenic-sedimentary bedrock, resistivity. 3000-3500 Ohmm

COMPARISON OF THE GEOPHYSICAL AND GEOLOGICAL DATA

(Geological Profile Dhame L. and Dhima N.)



Sliding plain

Tectonic line

Geoelectric border

Electrical sounding

Borehole

Diabase breccia

Diabase

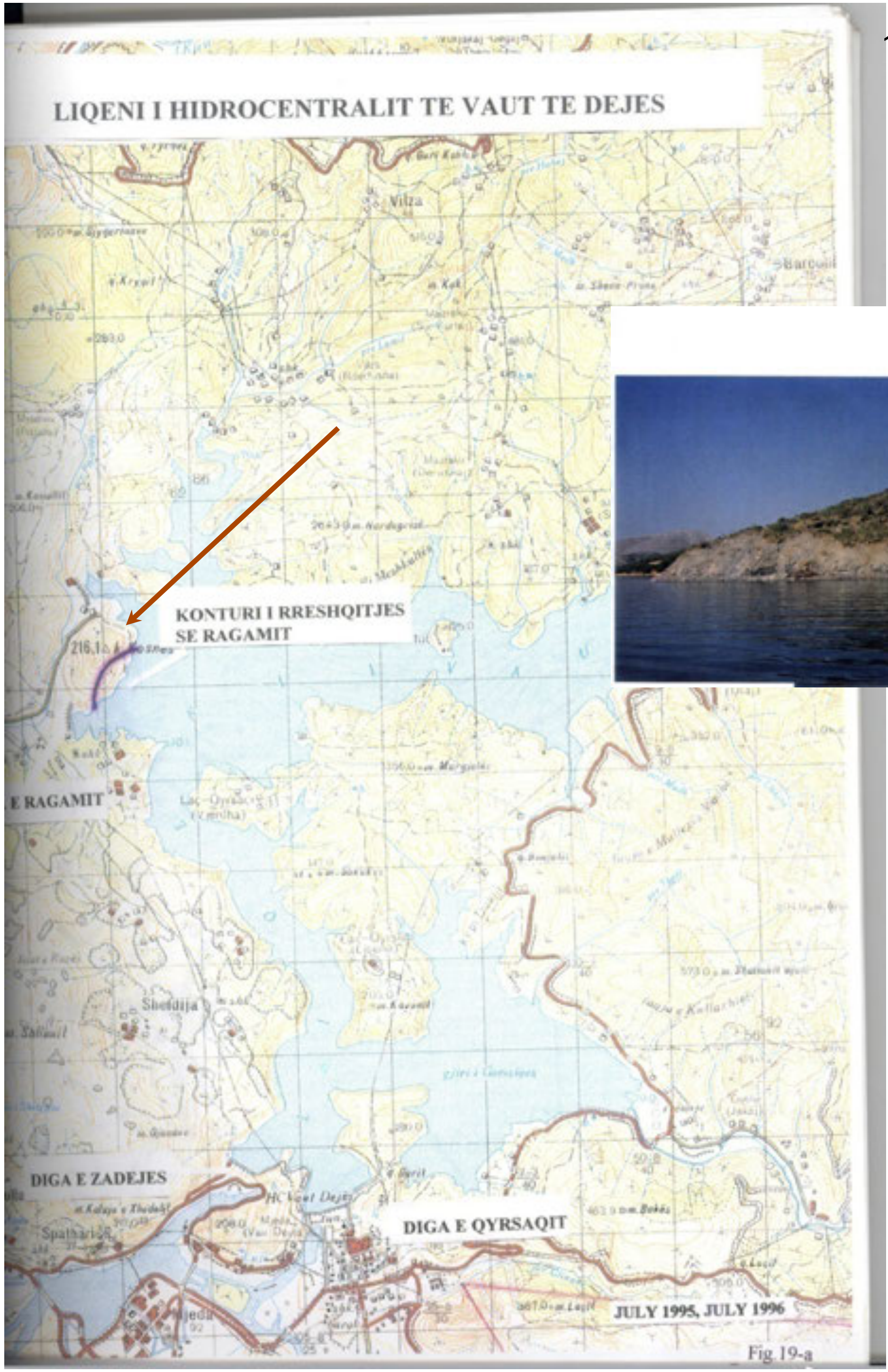
Schist

Diabase breccia

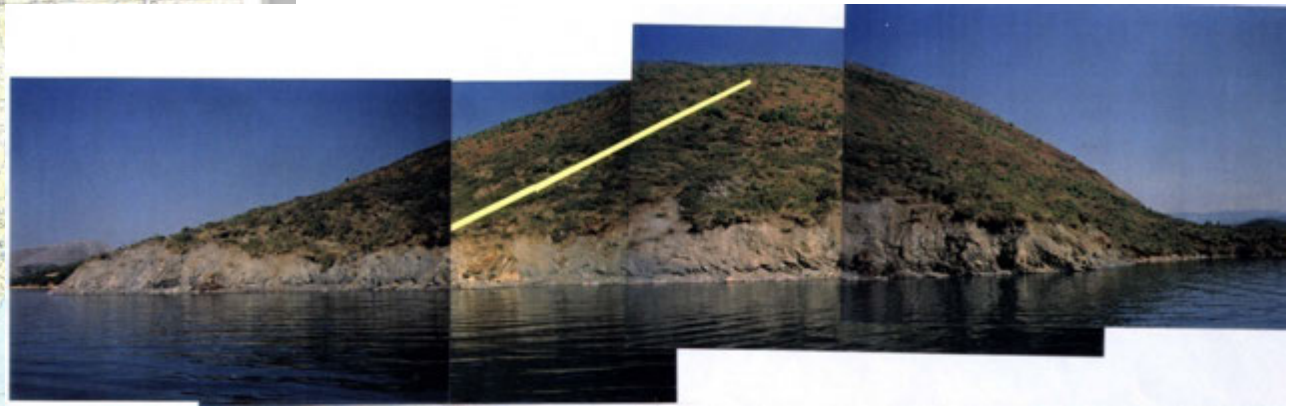
Aluvium

- Results that the Porava landslide is the biggest slide studied till now. The lower plane of this landslide is located about 100 - 160 m deep. It separates the volcanogenic-sedimentary rocks with very low petrophysical characteristics from the volcanogenic-sedimentary deposits untouched by the sliding phenomena. The total volume of the whole sliding body, from some approximate calculation based on these preliminary geophysical data, is estimated to be over 40 million m3.
- The Porava slipping body is heterogeneous and composed of blocks.

PORAVA LANDSLIDE AND BROKEN HOUSES WALLS OF THE VILAGE

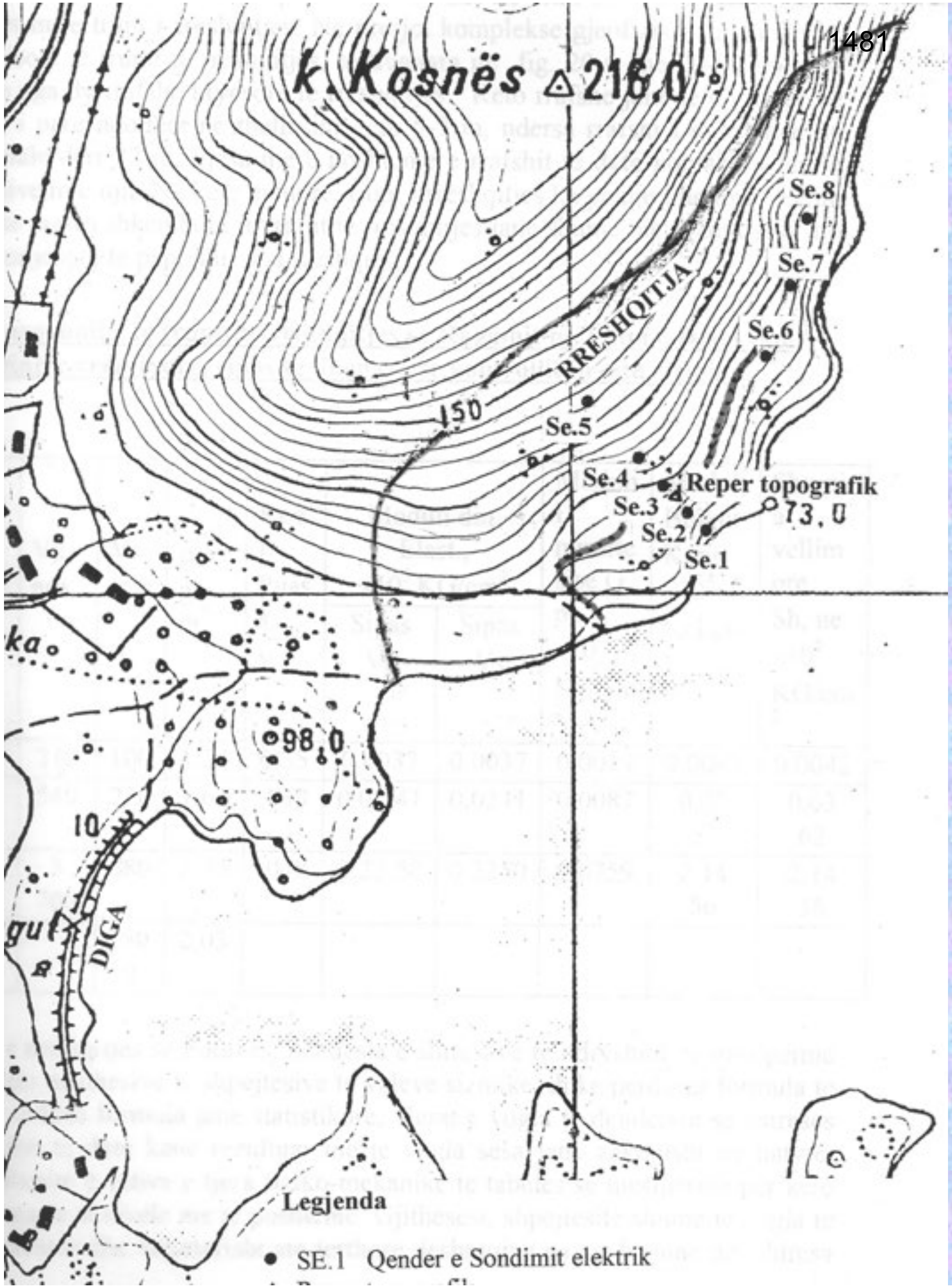


RAGAMIT, VAU I DEJES LANDSLIDE

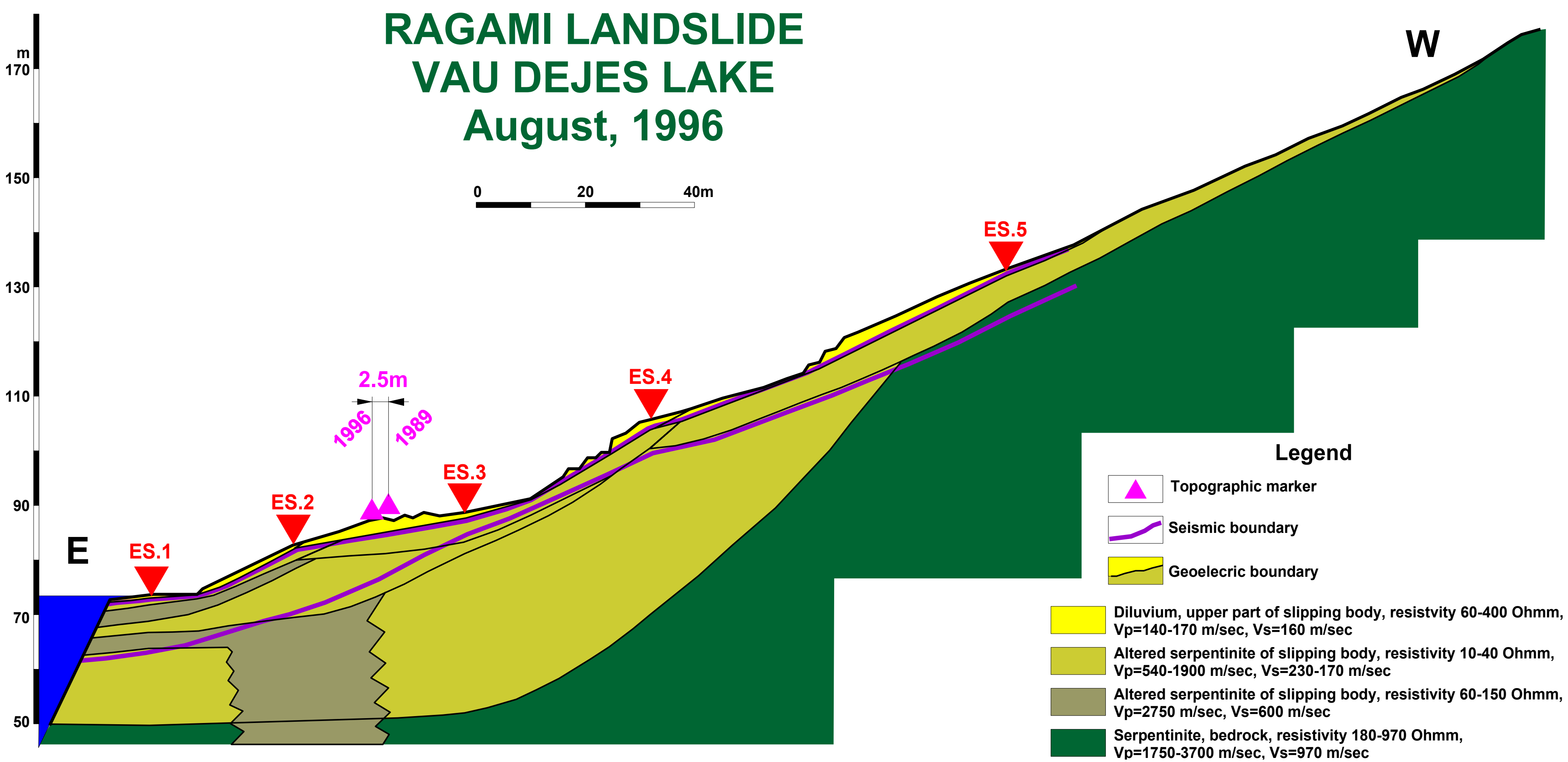


LANDSLIDE FRONT


RAGAMI LANDSLIDE
Vau i Dejes Lake
More...
Map
Satellite
Terrain
1000 ft
200 m
©2008 Google - Imagery ©2008 DigitalGlobe, GeoEye, Map data ©2008 Tele Atlas - Terms of Use



DINAMICS OF THE RAGAMI LANDSLIDE DEVELOPMENT



RAGAMI LANDSLIDE
VAU DEJES LAKE
August, 1996
0
20
40m
m
170
150
130
110
90
70
50
E
W
ES.1
ES.2
ES.3
ES.4
ES.5
2.5m
1996
1989
Legend
Topographic marker
Seismic boundary
Geoelecric boundary
Diluvium, upper part of slipping body, resistvity 60-400 Ohmm, Vp=140-170 m/sec, Vs=160 m/sec
Altered serpentinite of slipping body, resistivity 10-40 Ohmm, Vp=540-1900 m/sec, Vs=230-170 m/sec
Altered serpentinite of slipping body, resistivity 60-150 Ohmm, Vp=2750 m/sec, Vs=600 m/sec
Serpentinite, bedrock, resistivity 180-970 Ohmm, Vp=1750-3700 m/sec, Vs=970 m/sec

GEOELECTRIC LONGITUDINAL PROFILE
RAGAMI LANDSLIDE
VAUT DEJES LAKE
Tirana, December 1998

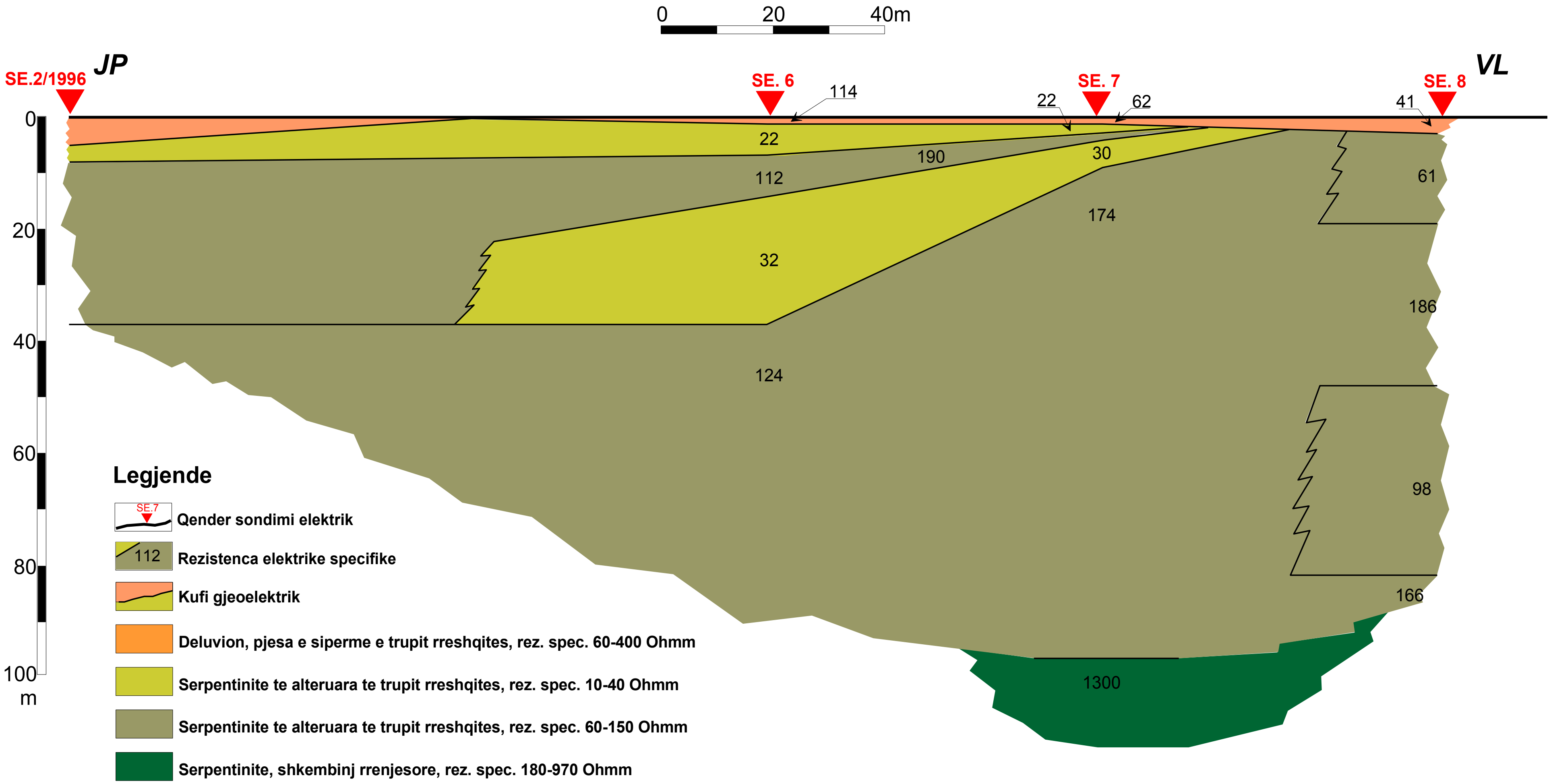
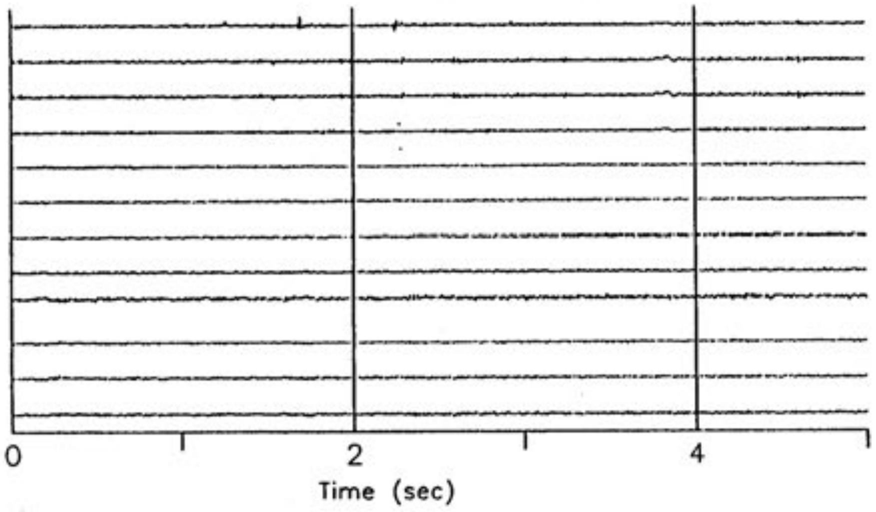


Fig.

Thick and high volume slipping bodies represent the Ragami active landslide in the shore area of the Vau Dejes Lake.

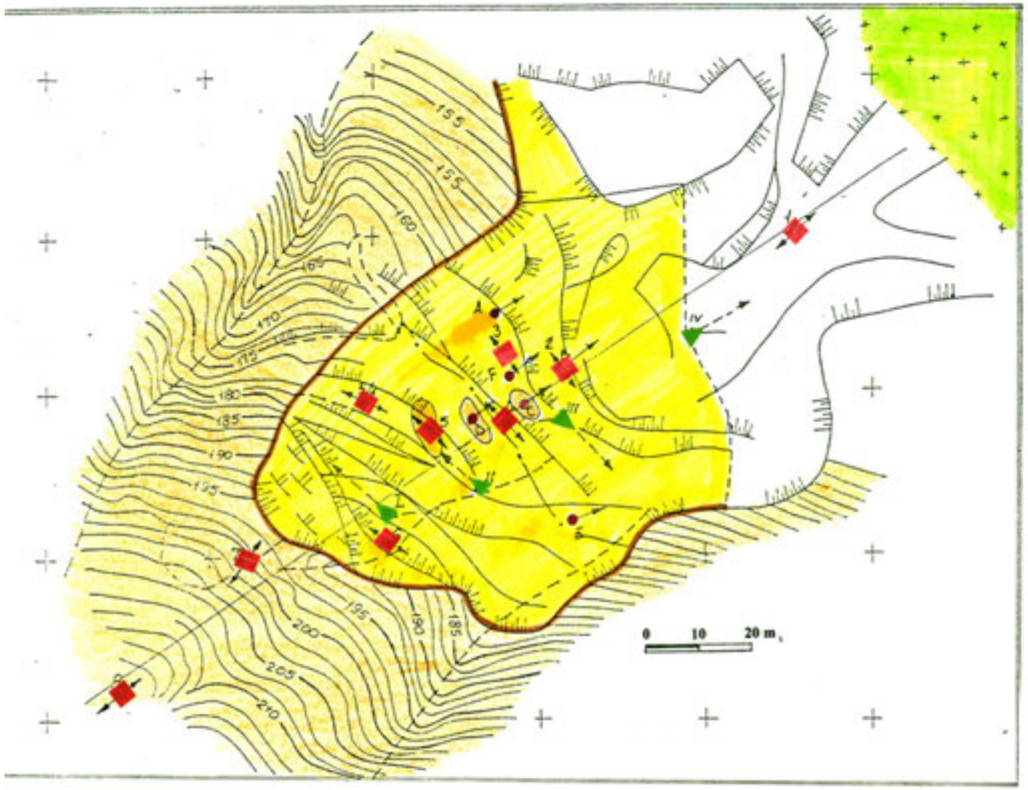


Outside of slipping body

Inside of slipping body

Natural seismic-acoustic activity in the Ragami landslide area

Topographic Sketch of the 1485
BENJA LANDSLIDE



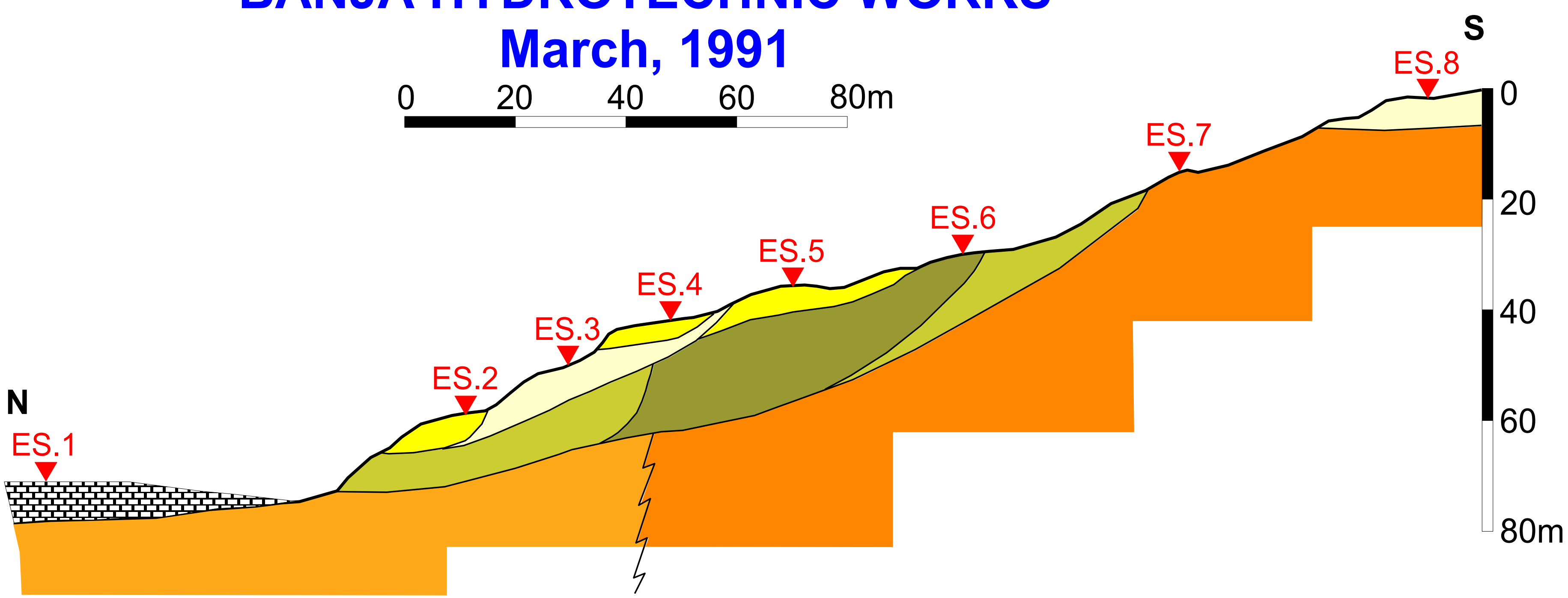
LEGJENDE

- Konturi i trupit te rreshqitjes
- Shkembinjte rrenjesore, flish
- Reper gjeodezik
- Qender e sondimit elektrik
- Qender e vrojtimit sizmik
- **Dige**

BENJA
LANDSLIDE

Foto 15. Pamje nga rreshqitja ne vepren hidroteknike te Banjes (Korrik 1987).

BANJA LANDSLIDE
BANJA HYDROTECHNIC WORKS
March, 1991



Legend

- Diluvium, siltstone, resistivity 10-20 Ohmm
- Flysch, slipping block, resistivity 30-40 Ohmm
- Sandy flysch, slipping block, resistivity 60 Ohmm, Vp=1000-3000 m/sec
- Sandy flysch, slipping block, resistivity 60-130 Ohmm, Vp=4500 m/sec
- Flysch, bedrock, resistivity 10-20 Ohmm, Vp=4100 m/sec
- Sandy flysch, bedrock, resistivity 15-60 Ohmm, Vp=5000 m/sec
- Geoelectric boundary
- Dam (in construction)

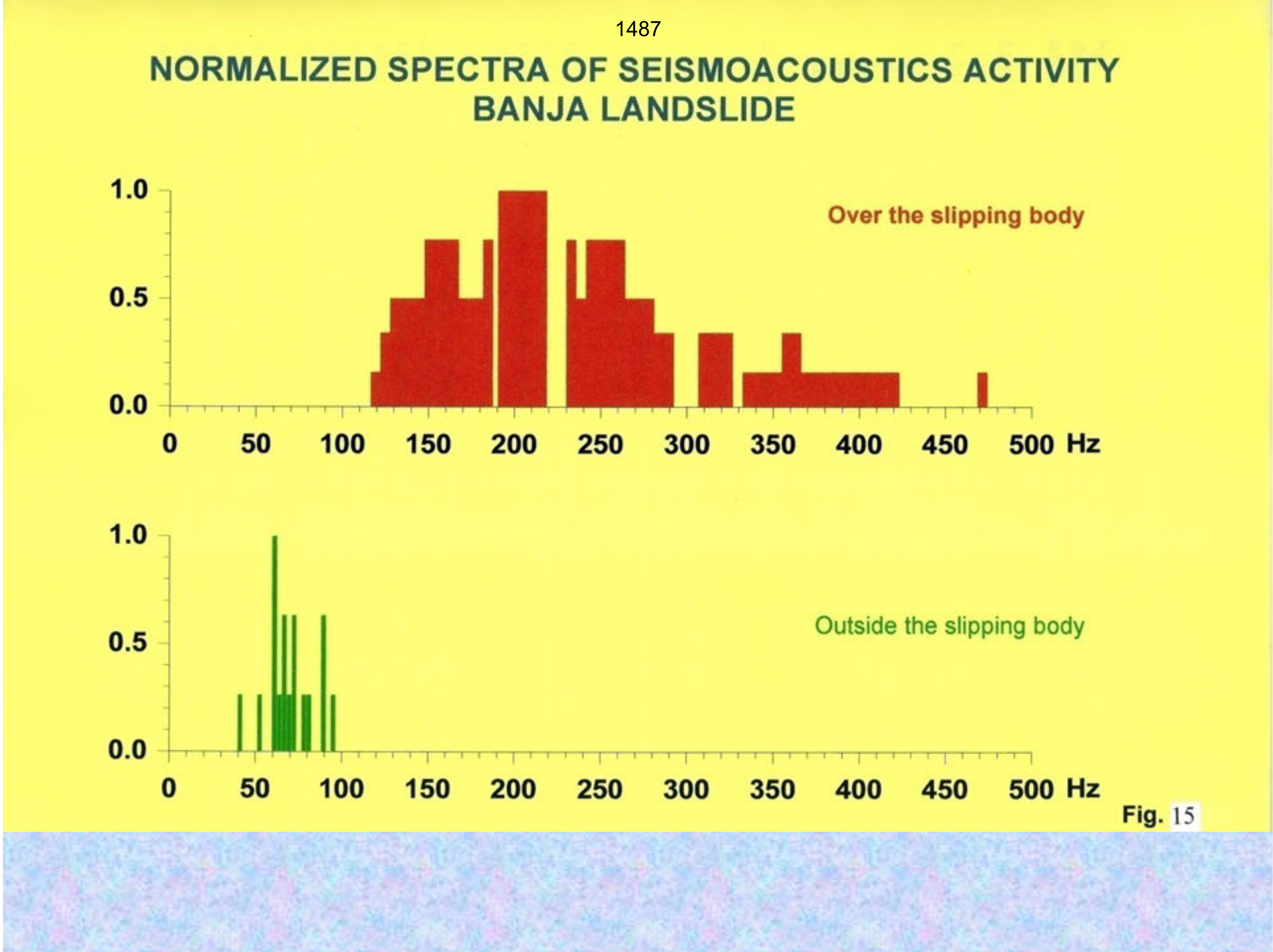
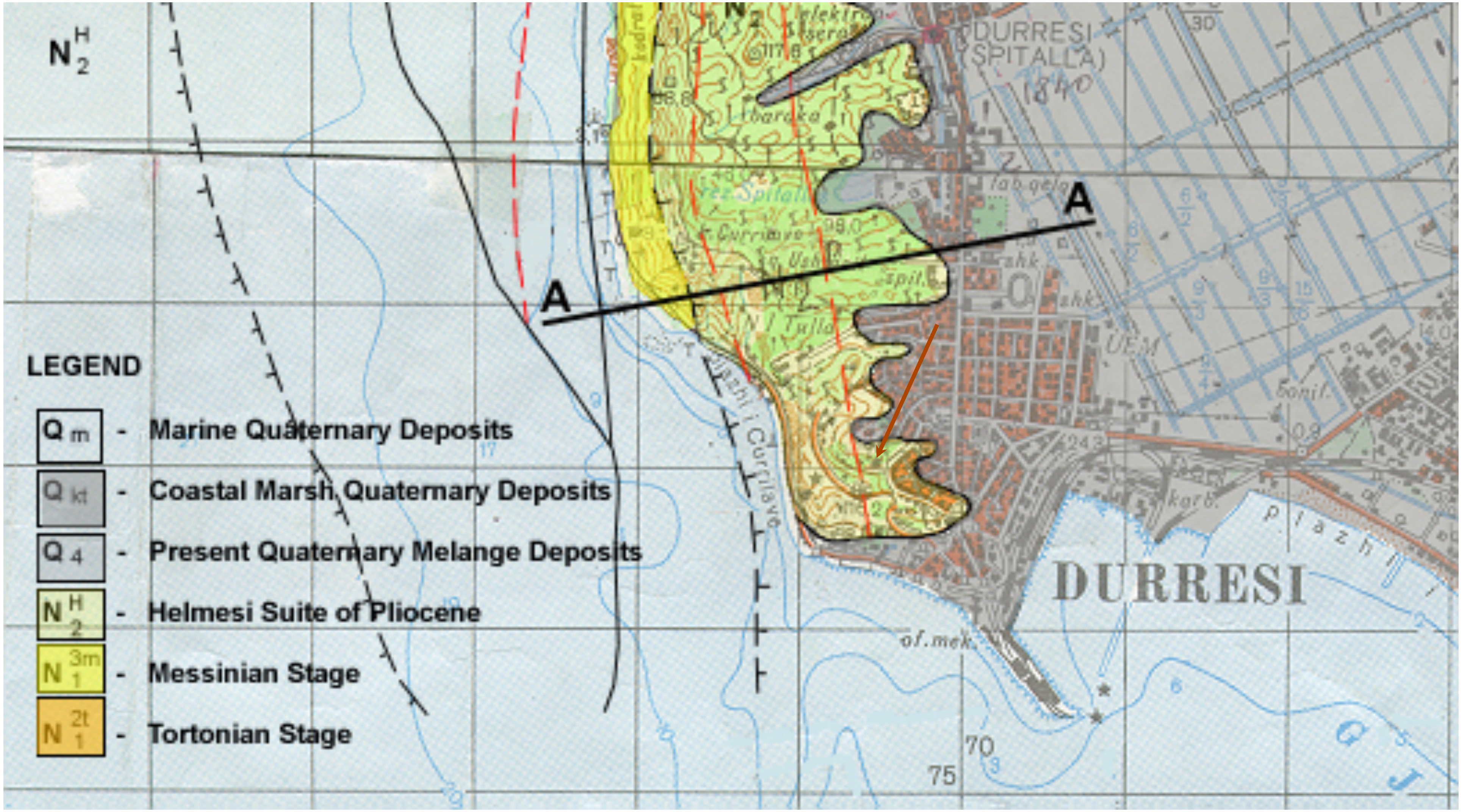

NORMALIZED SPECTRA OF SEISMOACOUSTICS ACTIVITY
BANJA LANDSLIDE
Over the slipping body
1.0
0.5
0.0
0
50
100
150
200
250
300
350
400
450
500 Hz
Outside the slipping body
1.0
0.5
0.0
0
50
100
150
200
250
300
350
400
450
500 Hz

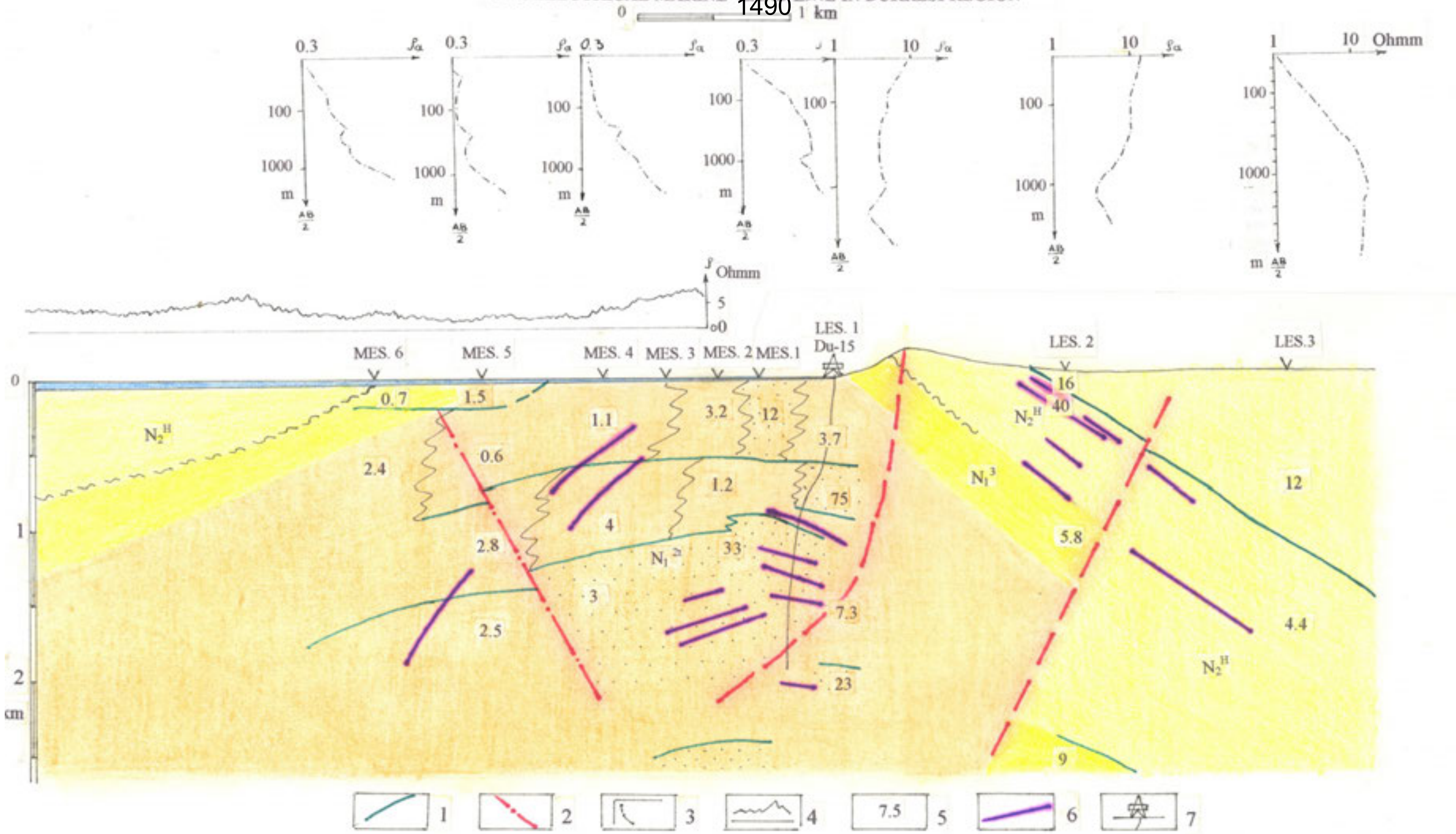
Fig. 15

LANDSLIDE IN THE NEOGENE LITTORAI HILLS, DURRESI CITY

GEOLOGICAL MAP OF THE DURRESI AREA



GEOELECTRICAL MARINE- LAND LINE IN DURRESI REGION



(Accordind to A. Frasheri)

1. Geoelectrical boundary; 2- Tectonic fault according to the geoelectrical data; 3- Electrical sounding curve; 4- Apparent resistivity profile, according to the electrical profiling with array A500M20N,C---→ ∞ ; 5- Digits in the line show the values of the electrical resistivity of the rocks; 6- Seismic horizon; 7- deep well.

VIEW OF DURRESI NEOGENE HILLS LANDSLIDE

CRACKS OF THE KING ZOGU VILLA WALLS

CRACKS OF THE KING ZOGU VILLA WALLS AND ROAD

Conclusions

Geophysical-engineering studies have a triple character:

a) the soil of the landslide area investigation,

b) evaluation of in-situ physical-mechanical properties of soils and rocks, and

c) in-situ monitoring of landslide phenomena dynamics.

- Based on the above analyses can be reached the following conclusions:

In the integrated geophysical-geological profiles are fixed studied landslides bodies. In these profiles were also clearly fixed the sliding plains.

In general, even though the geological conditions in which these slides have been developed are different, the plains have regular configuration, with maximum deepness in the center of the profile.

The extent of the landslide and the position of sliding plains were precisely fixed using the integrated geophysical survey.

- The slipping body, very often, is made of several slipping plains of block like character.

- Especially active today, are the slipping plains located 15 - 20 m deep. The slipping body over this plain is mainly made of deluvial - eluvial sediments, or rocky masses with very weak physical - mechanical characteristics. Their dynamic is causing more damages every day to the houses of the Porava village.

- The block like nature of the sliding bodies brings to the conclusion that in general these bodies can not fall immediately as a whole, in any kind of velocity. Only in particular cases, like in Banja, the fall occurs immediately.

- The structure of the slipping body and its dynamic stands in the foundation of the patterning on the landslide development. Besides the others, the height of the dam is directly defined from this pattern. Accepting the slipping body as a unique mass, has sent to the over heightening of the dam and greater expenses.

THANK YOU

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XXth Congress of the Carpathian Balkan Geological Association

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PECULIARITIES OF THE ULTRABASIC ROCK MAGNETISM AND PALEOMAGNETISM DATA OF ALBANIDES OPHIOLITE

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Abstract

1. The peculiarities of the ophiolite magnetization, and especially paleomagnetic studies results in Albania are generally presented in this paper. An immense ophiolitic belt is extend along the Inner Albanides from south to north of the country. The geological-petrological-geochemical and metallogenic sequences of the *tectonic sequence* and that of *cumulate sequence of the* ultramaphic formation represent important part of te ophiolitic belt. Different gabbros massifs, volcanic basalts and keratophyres have a large extension in the Mirdita Tectonic zone. Integrated petrophysical studies, have been performed. Rock magnetism is conducted in outcrops and rock samples over six lines. Have been determined space orientation of the vector of magnetic magnetization. Magnetism of the ophiolites is conditioned by the presence of the ferromagnetic mineral accessories, mainly by secondary magnetite, by the chemical and mineralogical transformations of the rocks during the serpentinization, by the redistribution of mechanical stresses, as well, during the process of the dynamometamorphism and tectonic activity. The orientations of the remnant magnetization vector of the ophiolite rocks were used as a supplementary information source about their formation conditions and consecutive changes in time.

Keywords: Magnetization, paleomagnetism, magnetic susceptibility, remnant magnetization.

1. Introduction

In the paper are presented the peculiarities of the ophiolite magnetization in condition of Alpine Folded Belt, including paleomagnetic studies results in Albania. In Albania was gained a good experience for the geophysical exploration of solid mineral deposits, which are concentrated in the ophiolitic belt. For their exploration carried out integrated geological-geophysical and geochemical ground and underground surveys. The geophysical complex includes gravity, magnetic and IP surface mapping at different scales, and the electro-magnetic underground survey. In order to get the geophysical documentation of the boreholes has been applied their well logging: electric, electro-magnetic, gamma, gamma-gamma, and magnetic surveys. Important part of the complex of geophysical direct explorations are gravitational and magnetic regional mapping at different scales and petrophysical studies, including density, magnetism, electrical resistivity, induced chargeability, and radioactivity of ores and rock formations.

2. Study methodic

Study of the rock magnetism is conducted by measurements of the magnetic susceptibility in outcrops in the field and induced and remnant magnetization determination in the rock samples. Sampling for the paleomagnetic studies have been carried out in fresh ultrabasic rocks, in gabbro, and in volcanic rocks of the Mirdita tectonic zone during 1995 year (Frashëri A, and Bushati S. 1995). Have been determined space orientation of the vector of magnetic magnetization, and for representative samples were performed thermal cleaning and demagnetization in the magnetic field of the alternative electric current. Sampling sites were located in six characteristic profiles, from south to the northern Albania.

3. Results analyse

The ophiolite belt extends in the territory of Mirdita tectonic zone of the Albanides. The ultramaphic formation, in general are characterized by two different geological-petrological-geochemical and

metallogenic sequences: *tectonic sequence* in lower part of geological cross-section, and that of *cumulate sequence*, over tectonic one. The lower part of tectonic sequence represents the hartzburgite facies with dunitic alternation, composed of fresh rocks in the lower levels up to medium serpentinized rocks in upper levels. The dunites represent lenses of thickness of some meters, stretching over hundreds of meters. The dunite with rare alternations of hartzburgite and lherzolite are predominant inside the cumulate sequence**.**

The ultrabasic rocks have a magnetism, which changes in a broad band, conditioned by the presence of the ferromagnetic mineral accessories, mainly by secondary magnetite and less by the magnetized accessory chrome spinel (Tab. 1, fig. 1, photo 1). The fresh dunites and hartzburgites of tectonic sequence are not magnetic (table 1). The ratio $Q_n=I_r/I_i>1$ is approximately in 48% of the cases, with average value 2,3 for dunites and 1,9 for hartzburgites. That reveals the influence of the thermal nature of the remnant magnetization. With the increasing of the activity of cataclasis, magnetism is strengthened, especially the natural remnant magnetization. With the increase of the serpentinization process, the magnetization of dunites and hartzburgites gets stronger. This can be explained by the increase of the secondary magnetite and the thermo-remnant magnetization. The magnetism of the serpentinites has a particularly characteristic: Its values vary in a wide range, from practically unmagnetic to strong magnetic (Tab. 1). This phenomenon can be explained not only by the degree of serpentinization, because the quantity of serpentines in the rocks does not always determine the quality of secondary magnetite. Therefore, ultrabasic rocks can be classified as nonmagnetic, weakly magnetic and strongly magnetic ones. These great changes of the remnant magnetization, induced magnetization and of the Q_n ratio for ultrabasic rocks, in general, and for the serpentinites in particular, is conditioned, not only by the contain of the secondary magnetite. These phenomena are conditioned by the chemical and mineralogical transformations of the rocks during the serpentinization and by the redistribution of mechanical stresses, as well, during the process of the dynamometamorphism and of the tectonic activity.

The magnetic properties of the chrome spinel ore and the ultrabasic rocks.

(Frashëri A, 2008)

Table 1

Kind of ore or rock	**Quantity of samples**	Induced magnetization I_i, $*10^{-5}$ units (SI)			Remnant magnetization I_r, $*10^{-5}$ units (SI)			$Q_n=I_r/I_i$		
		Min.	Max.	Mode	Min.	Max.	Mode	Min/Max	Aver.	% of samp with $Q_n>1$
Dunite	85* 32**	0	700	10±10 50±30 200±80	10	1800	300±70	1.2/5	2.3	0.5
Serpentinized dunite	20	38	1000	350						
Harzburgite	109* 56*	0	700	15±15 300±100	20	1000	300±100	1.2/13.8	1.9	0.3
Serpentinized harzburgites	87* 14**	40	1000	300	20	1300	350±150	1.0/2.4	1.77	0.6
Serpentinites from dunites	82	0	3700	150±70	5	70000	300±90	1.0/31.0	1.8	0.6
Serpentinite from harzburgites	68	0	1100	250±50	5	9500	150±60	1.0/23.0	2.1	0.5
Pyroxenites	102	10	720	350±60	10	71000	150±90	1.0/114	4.0	0.7
Gabbro pegmatites	21	0	270	50	170	250		1.2/4.5	1.3	

Note: * samples quantity of I_i measurement; ** Samples quantity of I_r measurement

The magnetism of pyroxenite varies within wide limits. However, the majority of pyroxenite are weak magnetic (Table 1). The ratio Q_n has an average value 4,0, but in particular samples up to 114. In these cases, the remnant magnetization has a thermal nature, under the influence of the magnetic field of the earth and surrounding rocks. Volanic basalts and keratophyres in northern massifs in Mirdita tectonic zone have a remnant magnetization that vary o,061-3,716 A/m, although their magnetic susceptibility is higher, up to $102.500.10^{-6}$ SI units. Their magnetization is conditioned by content of secondary magnetite. In South-East of Albania have been observed a basalt individualization with the remnant magnetization I_r=117,803 A/m.

Gabbros magnetizations vary in different massifs. In Kurbneshi, at North-East of Albania, the gabbros have lower level of magnetization, averagely I_r=0,007 A/m and magnetic susceptibility 535.10^{-6} SI units. In Qafzezi village, South-Easter of Albania, gabbros have stronger magnetization; I_r=52,825 A/m.

.Analyse of the stereographic projections of the remnant magnetization vector shows that parallel with common orientations are observed nearby samples with different orientation, positive and inverse negative. Such phenomenon argues the superposition of the isothermal and chemical and thermal magnetization on remnant thermal magnetization. Although these differences of the ophiolite magnetization, in some massifs is preserved approximate orientation of the vectors of remnant magnetization (Fig. 2). Predominant orientation of remnant magnetization vector have and azimuth D=284^o for pillow lava and D=297^o for volcanic basalts in central part of Mirdita zone. Azimuth D=267^o of the magnetization vector have gabbro of Kurbneshi massif in this part of Mirdita zone.

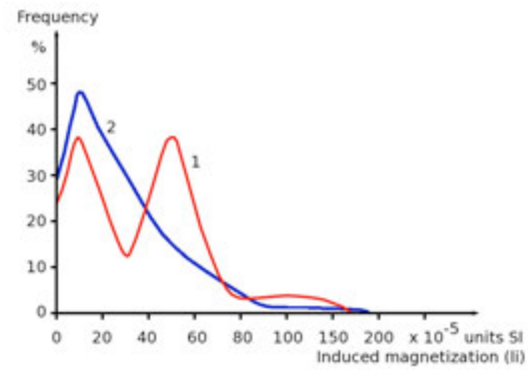

Fig. 1. The variation curves of induced (I_i) magnetization of the dunites (1) and hartzburgites (2), Ragami deposit, Tropoja Massif (Frashëri A. et al., 2008).

Photo 1. Serpentinit from dunite, with fissures of different ages, chrysotile-asbestos and magnetite, Kam deposits. Magnetic susceptibility χ>3000x10^{-5} units SI. Thin section, enlargement 35x, Nicoles parallel. (Frashëri A.et al. 2008).

In contrary with volcanic rocks and gabbros of central part of Mirdita zone, the hartzburgites are represented by a dispersion of the azimuth of magnetization vectors in large limits in Bulqiza ultrabasic massif, D=60^o – 300^o, as well as preserve the positive sense of the vectors (Fig. 2). This great variation of the direction of azimuth of magnetization vectors is conditioned by serpentinization process of the ultrabasic rocks, even for low level of the serpentinization. In the North-Eastern edge of the ophiolitic belt of Albanides, in he Komani site, the volcanic rocks have e clockwise rotation, analogue with External Albanides (Fig. 2). The magnetization of gabbros in Qafzez Massif in South-East of Albania, has an useful magnetic signal after cleaning and demagnization, with a vector oriented I=60.9^o and azimuth D=282^o. This direction is approximate with orientation of the magnetism vector of the gabbros massif in Chalkidiki, Greece, D=312^o and I=68^O. The ophiolitic belt of the Chalkidiki was undergone two tectonic phases: first a counterclockwice rotation during Later Jurassic-Lower Cretaceous and the second one a clockwise rotation during Tertiary (Edel J.B. et al., 1991).

4. Conclusion

2. The magnetism of the ultramaphic rocks vary within broad limits. Fresh rocks are not magnetic. The serpentinites are usually magnetic and sometimes strongly magnetic.
3. Magnetism of the ophiolites is conditioned by the presence of the ferromagnetic mineral accessories, mainly by secondary magnetite, by the chemical and mineralogical transformations of the rocks during the serpentinization, by the redistribution of mechanical stresses, as well, during the process of the dynamometamorphism and tectonic activity.
4. Analyse of the stereographic projections of the remnant magnetization vector shows that parallel with common orientations are observed nearby samples with different orientation, positive and inverse

negative. Such phenomenon argues the superposition of the isothermal and chemical and thermal magnetization on remnant thermal magnetization.

5. Although the differences of the ophiolite magnetization, for some massifs is preserved approximate orientation of the vectors of remnant magnetization. In these cases, the study of the orientation of the remnant magnetization vector of the ophiolite rocks can be used as a supplementary information source about their formation conditions and consecutive changes in time.

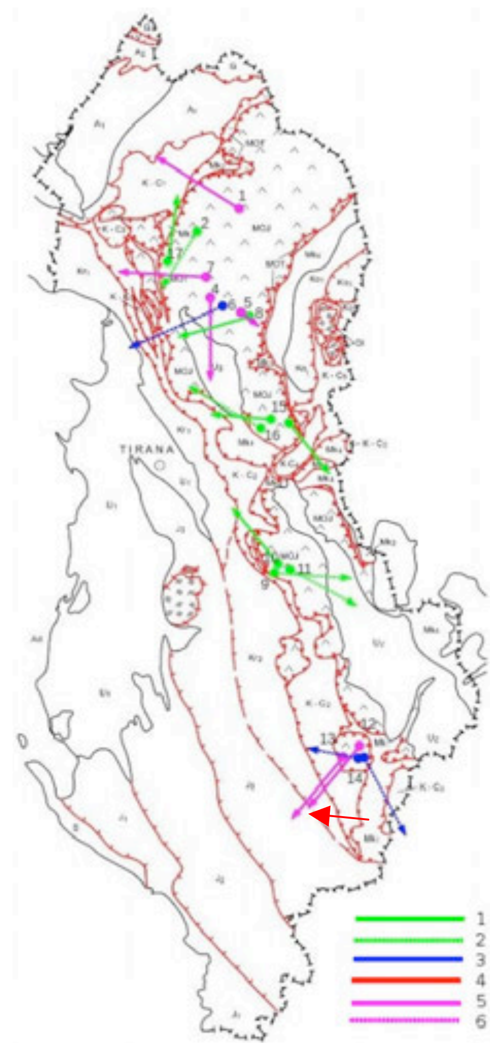

Fig. 2. Declination of the magnetization vectors of the ophiolite belt in Mirdita tectonic zone of the Albanides.

Tectonic zones:
Internal Albanides:
M- Mirdita zone
G- Gashi zone
Ko- Korabi zone

External Albanides:
A- Albanian Alps
K-C- Krasta-Cukali zone
Kr- Kruja zone
J- Ionian zone
S-Sazani zone
U- PeriAdriatic Depression

Magnetic declinations:
1- J > 0 Ultrabasic rocks
2- J < 0 Ultrabasic rocks
3- J < 0 Gabbro
4- J > 0 Gabbro, remnant magnetization after demagnetization
5- J > 0 Volcanic rocks
6- J < 0 Volcanic rocks

5. Acknowledgments

We express our thanks addressed to Prof. Dr. Condopoulou Despine, Gelogical School, Aristotle University of Thessaloniki, and to Pruner Peter, Magnetic Laboratory of Institute of Geophysics, Academy of Science. Prague, for the help they gave us for paleomagnetic meassurements to their labs of the ophiolitic rocks, during 1995 year,

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PAPER TITLE: **GEOTHERMAL RESOURCES IN KOSOVA AND THEIR USE, IN THE FRAMEWORK OF THE COUNTRY ENERGETIC BALANCE**

PRESENTING AUTHOR: **ATIFETE ZUNA**

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SS9		SS18							

GEOTHERMAL RESOURCES IN KOSOVA AND THEIR USE, IN THE FRAMEWORK OF THE COUNTRY ENERGETIC BALANCE

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1. INTRODUCTION

Kosova has got the geothermal resources of a low enthalpy and mineral waters, new technologies of the direct use, which represent the base for a successful application of modern technologies in Kosova, to achieve the economic effectiveness and success of a complex direct use.

At the present, geothermal, hydrogeological, hydrochemical, biological and medical investigations and studies on thermal and mineral water resources are ongoing in Kosova. The aims of the new studies are to examine, demonstrate and disseminate the positive technical and financial aspects of transfer and utilization of innovative geothermal energy technologies in Kosova. According to their results, the assessment of the perspective level of the best areas in country will be necessary. After such evaluation can be start the investments in these areas. Integrated exploitation and cascade direct use of the geothermal energy will be realized by an integrated scheme of geothermal energy, heat pumps and solar energy.

2. GEOTHERMAL REGIME

The Geothermal Regime of the Kosova geological structures is conditioned by tectonics of the region, lithology of geological section, local thermal properties of the rocks and geological location (Fig. 1).

2.1. Temperature

The geothermal field is characterized by a relatively low value of temperature in the Rrafshi Dukagjinit region. The temperature at 1000 meters depth varies from 25 to almost 30°C (Fig. 2). The temperature is 70-75^{o}C at the depth 3000 meters, and 120-130^{0}C meters depth. Going from southeast to northwest, towards Prishtina, the temperature at 1000m depth vary from 30 to 40^{o}C, and 140^{0}C at 5000m depth.

2.2. Heat Flow Density:

Regional pattern of heat flow density in Kosova territory is presented in the Heat Flow (Fig. 3) Map. There are observed two particularities of the scattering of the thermal field in Kosova:

Firstly, minimal value of the heat flow is equal to 45-50 mW/m^2 in the Rrafshi Dukagjinit region. These phenomena have taken place owing to the great thickness of sedimentary crust.

Secondly, toward North-East the Heat Flow Density is augmented to 90 mW/m^2. A high flow density anomaly belt extends from south-west of Budapest, toward Belgrade, Prishtina up to Skopje. Maximal values of the heat flow density in this belt are 150 mW/m^2. The contours of this Heat Flow Density anomaly belt partly give a clear configuration of ophiolitic belt in Dinarides, and present a shallow depth of the Earth granitic crusts, too. Radiogenic heat generation of the ophiolites is very low. In these conditions, increasing of the heat flow in the ophiolitic belt is linked with heat flow transmitting from the depth. The granites of the crystalline basement, with the radiogenic heat generation, represent the heat source.

2.3. Geothermal energy resources in Kosova

Geothermal energy of low enthalpy resources is located in different areas of Kosova. Thermal waters with a temperatures that reach values of up to 50^{0}C, are sulfate, sulfide, calcium, magnesium, hydrogen carbonate Sodium methane type. Kosova geothermal areas have different geologic and thermo-hydrogeological features. Thermal sources are located in the Inner and the Outer Dinarides are the largest geotectonic units, geothermal zones, which represent the areas with bigness geothermal resources.

Geothermal aquifer is represented by a The Inner Dinarides are built up of Paleozoic terrigenous and marine sediments, Triassic calcareous and Cretaceous ophiolitic-radiolitic associations, Paleogenic flysch and neogenic molasses formation with numerous fissures and micro fissures

Tab. 1 *Thermal water springs and wells in Kosova*

Type of the source	Location	Temperature (°C)	TDS, (mg/l)	Yield, l/sec
g	Studenica	25		
	Pecka banja	50	1.554	17.5
	Banje	28		
	Cecevo	24		
	Rudnik banja	25		
	Banjska	50	1355	÷4.9
	Banjski topli	23		
	izvori	19		
	Slatina	37		22
	Banja e klokotit	27		
	Drenica			

3. DIRECTIONS FOR THE DIRECT USE OF GEOTHERMAL ENERGY OF LOW ENTHALPY IN KOSOVA

The geothermal situation of low enthalpy in Kosova offers three possibilities for the direct use of geothermal waters energy. Geothermal energy exploitation must be realized by integrated scheme of geothermal energy, heat pumps and solar energy, and cascade use of this energy (Frashëri A. 2001, Frashëri A. et al. 2008, 2010). This scheme gives an environmental benefit by using renewable energies (geothermal and solar energy), new technologies (heat pumps) and energy savings (cascade scheme). Cascade scheme should be used to fulfill the thermal energy demand for the selected area in order to get the maximum benefit from geothermal energy and the minimum energy supply from heat pumps.

Firstly, the Ground Heat can be use for space heating and cooling by Borehole Heat Exchanger-Geothermal Heat Pumps modern systems.
Secondly, thermal sources of low enthalpy and of maximal temperature up to 50 ^oC.
Thermal waters of springs may be used in several ways:
1. Modern SPA clinics for treatment of different diseases and hotels, with thermal pools, for development of eco-tourism. Such centers may attract a lot of clients not only from Kosova, because the good curative properties of waters and springs are situated at nice places.

2. The hot water can be used also for heating of hotels, SPA and tourist centers, as well as for the preparation of sanitary hot water used there. Near these medical and tourist centers it is possible to build the greenhouses for flowers and vegetables, and aquaculture installations.

3. From thermal mineral waters it is possible to extract very useful chemical microelements as iodine, bromine, chlorine etc. and other natural salts, so necessary for preparation of pomades for the treatment of many skin diseases as well as for beauty treatments. From these waters it is possible to extract sulphidric and carbonic gas.

Consequently, the sources of low enthalpy geothermal energy in Kosova which are at the same time the sources of multi-element mineral waters, they represent the basis for a successful use of modern technologies for a *complex and cascade exploitation* of this environmental friendly renewable energy, achieving a economical effectiveness. Such developments are useful also for the creation of new working places and improvement of the level of life for local communities near thermal sources.

5. RENEVABLE ENERGY RESOURCES IN KOSOVA AND ROLE OF EOTHERMSL ENERGY IN COUTRY ENERGETIC BALANCE

Total contribution expected of each renewable energy technology to meet the binding 2020 targets and the indicative interim trajectory for the shares of energy from renewable resources in electricity, heating and cooling and transport.

Electricity sector: According to RES targets set by the AI, main renewable sources for electricity generation the will be hydro, onshore wind and smaller portion will from solid biomass and solar sources. In 2020, the planned RES in electricity comprises of 79% of hydro, 14.8% of onshore wind, 5.2% of solid biomass and only 1% of solar photovoltaic.

Heating and cooling : The use of biomass for heating will keep its dominating role for achieving RES targets in heating and cooling by 2020 followed by some use of solar energy and heat pumps. In the year 2020, the planned RES share in the gross final consumption in heating and cooling will comprise 95.2% solid biomass, 4.3% solar and only 0.4% heat pumps using aero-thermal, geothermal and hydrothermal energy.

Tab.2 **Estimation of the available potential in Kosovo for each renewable energy technology in heating-cooling 2010-2020** (ktoe)

						2014	2015	2016	2017	2018	2019	2020
Geothermal (excluding low temperature geothermal heat in heat pump applications)	0	0	0	0	0	0	0	0	0	0	0	0
RE from heat pumps - of which aero thermal - of which geothermal - of which hydrothermal	0	0	0	0	0	0.01	0.06	0.26	0.52	0.77	1.03	1.29

6. CONCLUSIONS

1. Kosova has geothermal energy resources, which can be direct use as alternative, environmental friendly energy.
2. Resources of the geothermal energy in Albania are:
    a) Natural springs and deep wells with thermal water, of a temperature up to 54^0C.
    b) Heat of subsurface ground and water, with an average temperature of 25-54^oC and depth Earth Heat Flow.

3. Construction of the space-heating system, based on direct use of ground heat, by using of the shallow borehole heat exchanger (BHE)-Heat Pumps systems, is actually most important direction of the use of geothermal energy.

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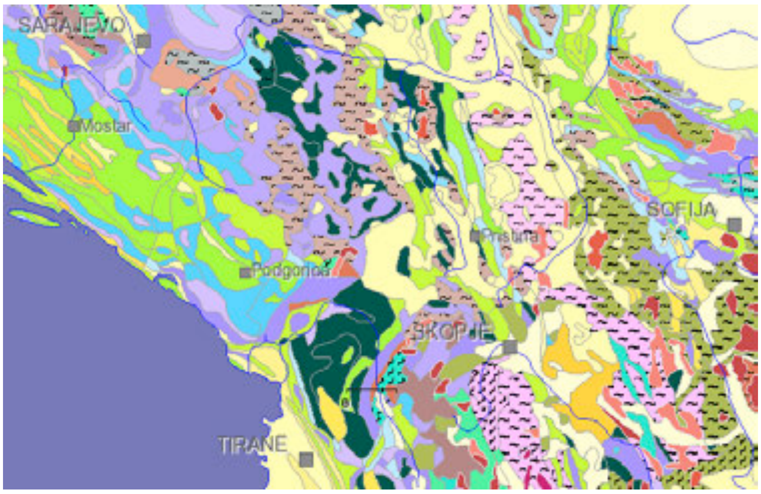

Fig. 1. Geological Map of Western Balkan (IGME, Athens)

Fig. 2. Temperature Map at 1000m depth (Geothermal Atlas of Europe, 1992)

Fig. 3. Heat Flow Density Map, (Geothermal Atlas of Europe, 1992)

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IMPACT OF THE CLIMATE CHANGE ON ALBANIAN ECOSYSTEMS

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Abstract

The general cascade impact of the climate change on Albanian Adriatic ecosystems are presented in the paper. The study is based on the results of inversion of 6 temperature logs data for the ground surface temperature history in Albania, and climate change according to the multi annual meteorological data from different regions of Albania. The wells and the meteorological stations are located in Sedimentary Basin of Albania, at the field region in the west of Central Albania and in the ophiolitic belt in the mountainous region of the northeast Albania.

Based on inversion data at coastal plane western region of Albania, GST history presents a gradual cooling before a middle of the 19th century, followed by 0.6 K warming. Climate warming of 0.6 K in the 20th century is observed also in mountainous northwestern Albania. This warming mainly after the second half of the 20th century is presented also by meteorological data: temperature, rainfall, and wind regimes.

There is estimated impact on continental water flow, created by atmospheric rainfalls, for wet and dry years are analyzed. Estimation of run-off discharges is carried out for two categories of river basins: first, for river systems, where run-off discharge is computed as a function of the altitude of water level river section. Second, for the water system of Scutary Lake-Drini River-Buna River, which is very complicated and is the single in Mediterranean Hydrography.

The warming impact on country climate, and ecosystems of Albania, thermal stress in the wetlands, lagoons and lakes have presented in the paper. Impact it is observed first of all on the biodiversity.

Keywords: Ground Surface Temperature, Climate Changes, Hydrology, Hydrographic System, Adriatic Sea, Environmental Impact.

1. Introduction

Detailed analyzes of the climate change in Albania is presented In the paper. Albania lies in a subtropical zone. It is a Mediterranean country. Winter is relatively short and mild, humid near the seaside areas. Summer lasts very long and it is hot and dry. To the east, in the mountain areas, the climate is Mediterranean mountainous. The climate in Albania varies from a region to the other, according to the location compared with the seaside, to the seasons, years, and centuries. The ground temperatures are conditioned by geographical position of the area, area's geology, and ground lithology, dynamics of the underground waters, meteorological conditions, and season. There is analyzed the ground surface history (GSH) and paleo-climate change according to the temperature measurements in the different wells in Albania. Climate changes during the last half of the XX century has been analyzed also based on the meteorological data.

Climate changes impact, geomorphology, lithology and geographical situation of the Albanian Hydrographic Network Catchment, are caused their impact on the water systems, and on the ecosystems.

2. Material and methods

Climate change are analyzed in two directions: firstly by temperature records in the deep wells and shallow boreholes (Frashëri, A. and Çermak, V. et al. 2004), and secondly by the multi annual meteorological observations data. The ground surface temperature reconstruction for long period, about 5 centuries, has been performed based on geothermal inversion results, and estimation of the ground surface temperature

changes at the past, according to the present-day distribution of the temperature at the depth, recorded in the borehole (Dimitriev V. I. et al. 1997, Frashëri A. et al. 1999).Six thermoplots were used for inversion of the ground surface temperature history.

Air and ground temperatures, total annual rainfall quantity, wind speed and wetness, which are analyzed by records in Meteorological Stations (Albanian Climate, 1978, Boriçi, M. and Demiraj E. 1990, Gjoka, L. 1990, Meteorological Bulletin 1931-2001, Mici, A. et al 1975, the data for 1985-2007 after Mustaqi V.). Borehole and meteorological stations are located at the plain region in the west of Central Albania, and in the mountainous region of the northeast of the Albania.

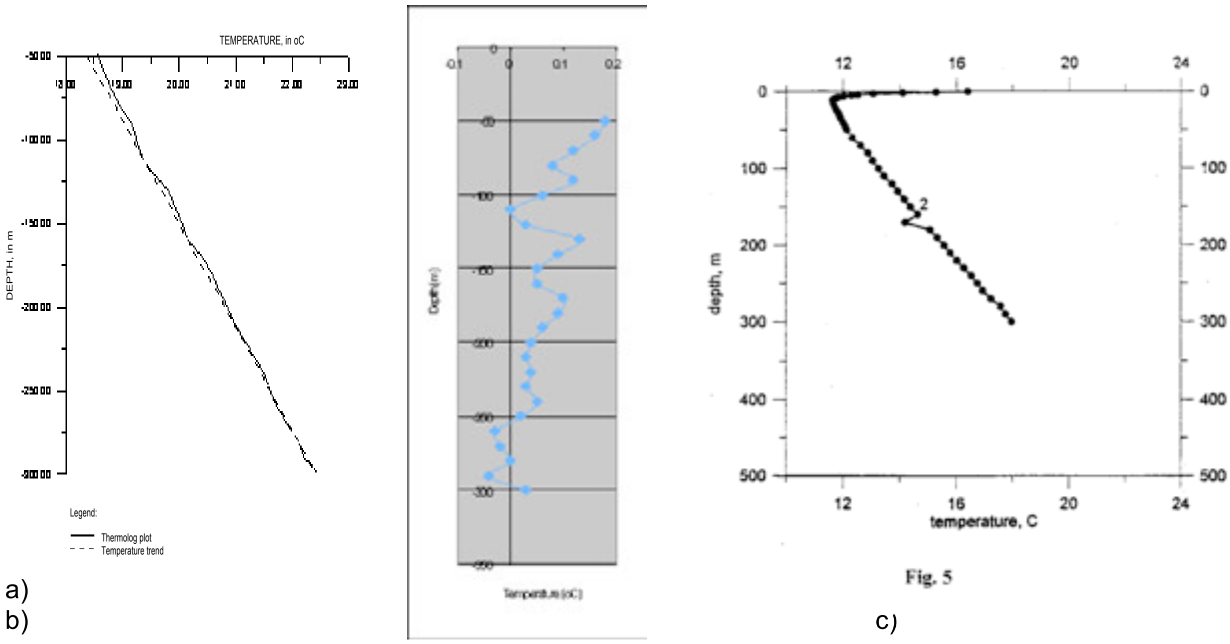
Water potential evaluation of the Albanian River Basin based on the multi annual archival data of the Albanian Hydrometeorological Institute of the Academy of Sciences (Pano N. 2008). The monitoring network has more than 22 meteorological and hydrometric stations, during the observed period 20-100 years. The methodology of the estimation of the water potential, have calculated the annual run-off discharge of the Albanian River System according to the corresponded types of the water supply, structure of the annual discharge distribution, and hydrogeographical types of the river catchment. All modeling and calculations have been performed for the model of dry and wet characteristic years, to analyze the climate impact on Albanian Hydrographic System.

3. Results and discussion

3.1. Climate change

The temperature log data of Kolonja-10 deep wells, which are located at coastal plane region of western Albania, are shown in fig. 1a , 1b. Ground surface temperature reconstruction of the temperature log data, as it is seen in figures 1a - 1b, and the GST history yielded by tighter inversion of Ko-10 (Fig. 2), presents a gradual cooling of 0.6 K, before a middle of the 19th century (Frashëri A., Čermak V., Šafanda, J., 1999). Later followed by 0.6 K warming, with a gradient 5.4 mK/years, that seems quite reasonable and is consistent with generally accepted ideas about the climate of the last 2-3 centuries.

In fig. 1c is presented temperature log of Vlahna 1127 borehole, Fig. 3 shows a GST history of Vl-1127, Gurth-595, Krasta-1 and Ragam-168 boreholes borehole, which is located in the mountainous regions of Northeast Albania. Some changes are observed in these regions as to the cooling of 0.2 K during the 19th century. Later, the warming trend is of 0.6 K during the 20th century, by a gradient 6.7 mK/year. Warming gradient increasing at mountainous regions, in comparison with coastal areas, is caused by intensive deforestation during the last half of 20th century.



a)
b)
c)

Fig. 1. Temperature log in deep well Kolonja-10 and its trend (a); Residual temperature after remove of trend values in thermo log of well Kolonja-10 (b)::;Temperature logs in borehole Vlahna 1127 in mountain region (c).

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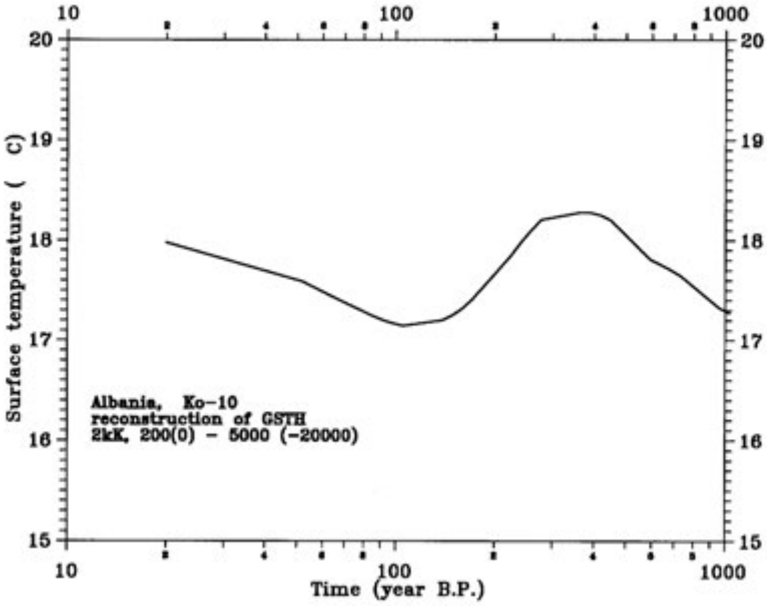

Fig 2. Ground surface temperature history according to temperature log of Kolonja-10 and Arza-31 wells (Frashëri A. et al 1999).

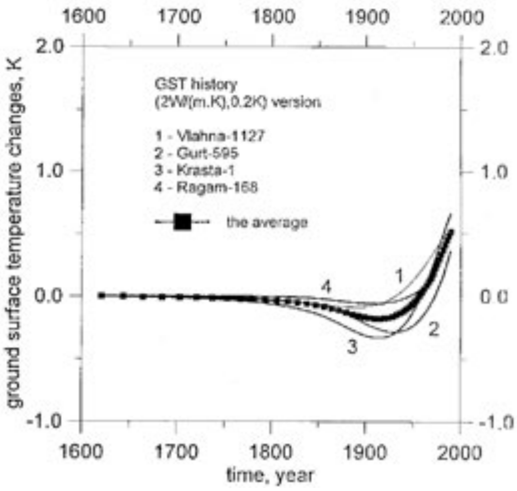

Fig. 3. Ground surface temperature history according to temperature logs of Vlahna.-1127, Gurth-595, Krasta-1 and Ragam-168 boreholes (Frashëri A. et al 1999).

Climate changes in Albania are observed also by the hydro meteorological studies. Fig. 4, 5 presents graphics of yearly average air temperature in Tirana and Shkodra Meteorological Stations, for the period from 1931 to 2000. As well known, Tirana is located in Central Albania. In general, the end of first half 20th century, observes a warming of climate, about 1^{o}C. Thirty quarter of 20th century is characterized by a cooling of 0.6^{o}C, and later, up to present a warming of 1.2^{o}C. The same climate changes are observed also at Shkodra City, in northwestern plane area of Albania. The cross correlation coefficient is C_c = 0.78 between variation curves of the average annual temperatures of both of these stations. Warming trend of maximum 1.2^{o}C, in particular after seventy years, is observed in all Albanian territory.

There are good cross correlation between variation curves of the average annual temperatures of Shkodra, Tirana and Kukesi, respectively C_c = 0.78 and 0.79. Weak cross correlation C_c = 0.58-0.68 is observed between temperature variation of the Kuçova area and other northern regions.

The meteorological data shows that the warming trend is not a monotone one. In short intervals are observed cooling and warming (Fig. 5). The meteorological studies have verified warming of the climate during the last quarter of the XXth century, too. It has been consisted that: “Around the 1980’s a warming trend is observed” (Boriçi M., Demiraj E. 1990, Demiraj E. et al 1996).

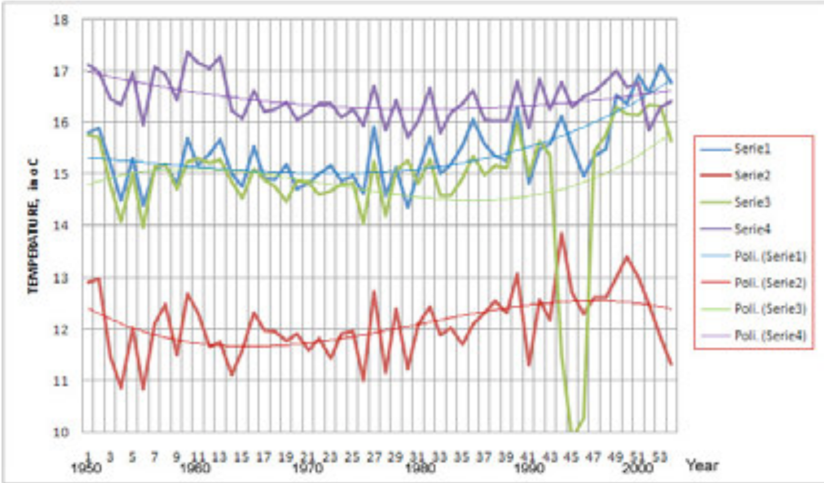

Figure 4. Air Average Annual Temperature Variation at Tirana (1), Kukesi (2), Shkodra (3), and Vlora (4) Meteorological Stations (Period 1931-2004).

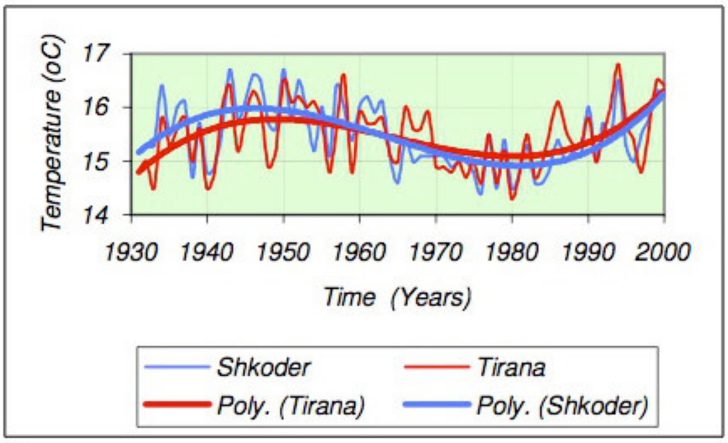

Figure 5. Air and Ground Average Annual Temperature Variation at Tirana and Shkodra Meteorological Station.

The warming period in Albania is accompanied with changes of the rainfall regime, wind speed and wetness. There are observed a decreasing of the total year rainfall quantity, for about 200-400 mm. (Fig. 12, 13, 14, 6).

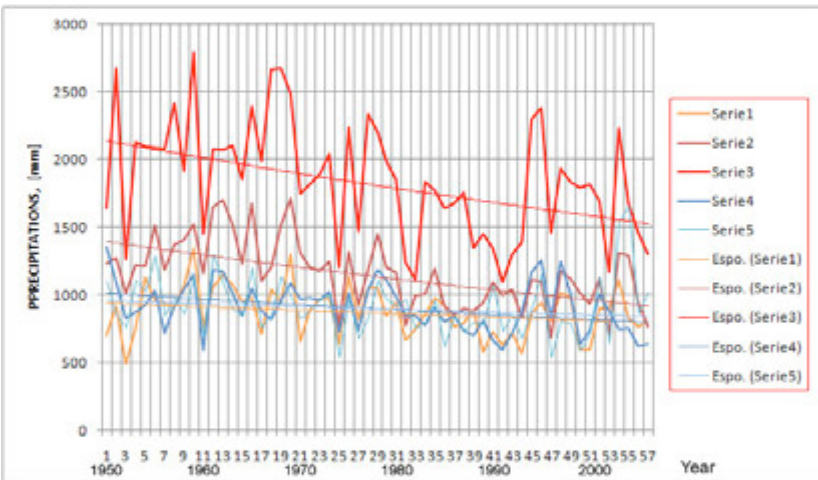

Figure 6. Total year rainfall quantity of the Kukësi (1) ;Tirana (2), Shkodra (3), Erseka (4) and Vlora (5) Meteorological Stations (Period 1930-2007).

Fig. 7 is presented the difference of the total year rainfall quantity in the most dry and wet years, respectively 1907 and 1960, in Shkodra region.

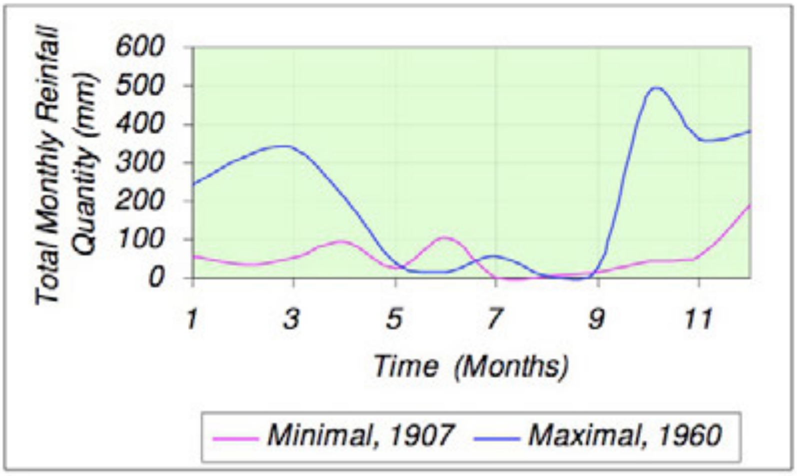

Figure 7. Total Year Rainfall Quantity in the most dry and wet year, respectively, of the Shkodra Meteorological Station (respectively 1907 and 1960 years).

In the dependence of the geographical location of the areas, changes the cross correlation of the rainfall quantity: Tirana area with Shkodra area C_c=0.62, with Korça C_c=0.81, Kuçova C_c=0.66, Kukesi C_c=0.88, Gjirokaster C_c=0.88, Vlora C_c=0.53, during the period of 1930-1970.

The warming have accompanied with decreasing of the wind speed about 1.5 m/sec and 5% increasing of the wetness, during the period of 1950-1994 (Fig. 8)..

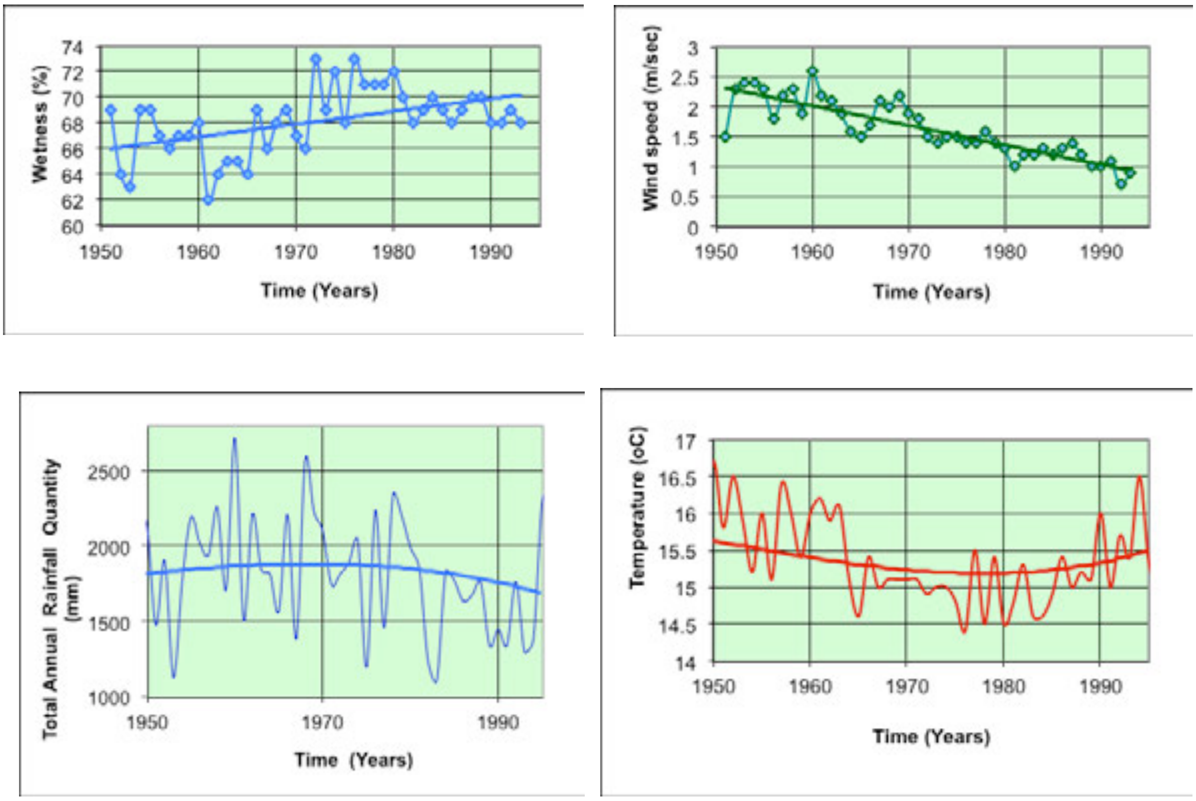

Figure 8. Air Average Annual Temperature, Total Year Rainfall Quantity, Wind Speed and Wetness Variations, at Shkodra Meteorological Stations (Period 1950-1994).

This warming is part of the Global Earth warming, during the second half of XX-XXI centers.

3.2. Discussion about the climate change impact on the Albanian environment.

Global warning has an integrated impact on Albanian ecosystems, too. First of all, main impact has been observed on water systems and water resources. Inland water resources change has its impact on the hydrographic regime of the Adriatic Sea, and particularly in the Albanian Adriatic Littoral (Frashëri A. & Pano N. 2003).

The water potentials of Albanian rivers system is $Wo = 41{,}249.10^9$ m^3. The discharge of the Albanian rivers into the Adriatic Sea varies in very wide limits, from Q_o=700-850 m^3/s for the hydrological years of a lower precipitation to Q_o=1850 2150 m^3/s for the years of a higher precipitation (Pano N. 2008). The volume of suspended material, which is transported through river network, is 65,7. 10^6 ton/year, while the turbidity Q_o=1 260 g/m^3. The river suspended matter deposits itself the river mouth in the Adriatic Sea. This process is very dynamic, making the Albanian river's mouths very active. Many changes of the riverbeds position formation of the coastal lagoon, etc. are observed time after time in these mouths. The wind regimes, wave refraction, sea currents, littoral sediment transport, have determined the general dynamics of the change of the Albanian coastline. The average annual temperature of the water varies from t=17,7°C in Shëngjini to 19,2°C in Saranda bays (Albanian Climate (Tables), 1978, Mici A. etc. 1975).

Adriatic coastal line from southern city Vlora up to Shëngjini Bay, in the north, have the marine accumulation flattened littoral, the marine erosion coast, and the submerged areas, where is observed marine ingression toward the mainland. In some areas there is cliffed coastline (Aliaj Sh. 1989, Frashëri A. 1987, Papa A. 1985, Pano N. 2008). Evolution of Albanian Adriatic coastline has a very intensive dynamics. Lithological changes from the shore to the continental slope area are gradually. There are observed some peculiarities, of river solid load distribution in shelf area, conditioned by marine currents. Filling process is intensive, generally, in river mouths. In these accumulative coastline areas there are some relatively small erosion sectors, which are located at the river mouths. In the shoal shelf zone, at the alluvial sea floor are observed the sandy splits. Marine deep erosion zones were developed over some sectors in accumulation littoral of Adriatic shoal. These zones are located in the uplifted side of the active reverse fault & thrust. In the Albanian Adriatic Littoral are observed some submerged areas, where is observed marine transgression toward the mainland. Submerged process is caused by the neotectonics activity, consequently there are observed a marine transgression. Lagoons have a total surface of about 150 km^2. Albanian lagoons represent crypto-depressions, with the floor under the level of the sea's bottom.

In the Albanian Adriatic Littoral are observed integrated factors of the coastline evolution: neotectonic's, erosion by marine currents and accumulation of the solid river discharge and eroded shore sediments that have directly an climate change impact. This factors complex has caused important changes on the coastline geomorphology, marine shoal and littoral landscape (Boçi S. 1981, Frashëri A. and Pano N. 2003, Pano N. 1994). Intensive change dynamics characterized different Albanian Littoral area, example Viluni Lagoon-Drini Bay up to Buna River delta. The decreased sediment load of the Drini River, caused by its diversion into the Buna, has triggered coastal recession, with greater intensity on the southern lobe of delta (Photo 1).

Photo 1. View of Buna River discharge in Adriatic Sea.

Temperature augmenting, which has caused increasing of the evaporation in the water systems, in the river system, reservoirs, wetlands, lakes and lagoon system, has caused a thermal stress, particularly in the water's flora and fauna. In very beautiful ecosystems of Albanian lagoon thermal stress has its impact, first of all on the biodiversity (Frashëri A. and Pano N. 2003). This stress is extended also in the shallow coastal waters; consequently there are observed diminution of the fish quantity. Impact on the Albanian hydrology and the Adriatic Sea), extends also on the intensity of erosion processes. The average annual temperature upgrading has started to affect the littoral forests, as well as vegetation inside the territory. There are observed the change of some Wood species, adding the types of trees that have lower

requirements for water; started increasing conifer trees. Reducing the area of the forest is another impact of global warming observed.
Even human activity is very intense in this time. In catchment river basins have been open much new agricultural soils in mountain regions, outside the scientific criteria, which have intensified erosion process. This process is also affected by deforestation, causing intensification of the process. Agricultural activities have often caused damage to wet soils. Other activities in some areas are related to the chemical plants, gas-content oil fields, oil refineries etc. Human activity and lack of treatment of wastewater pollution made possible agricultural, industrial and urban areas, which have negative impact on the ecological balance of the systems. It is necessary to set regular monitoring of this system, programmed and implemented restoration of environmental damage, as well as undertaking measures that will serve socio-economic development sustainable in the future. This integrated impact of the global warming becomes more evident in big cities and their surrounding areas. Global Warming is added with the increase of temperature, generating from city power system (Photo 2).

Photo 2. On Mount Dajti, which rises in the east of Tirana is no snow, as a result of microclimate changes: by heat that generate energetic system of the city.

4. Conclusions

Based on the results of inversion of the temperature logs data, recorded in deep wells and boreholes, for the evaluation of the ground surface temperature GST history and hydro meteorological data, we have arrived in following conclusions:

1. The climate at coastal plain region of Western of Albania was cooled of .6 K before of middle of 19th century. Later a warming of 0.6 K occurred, from last quarter of 19th until present-day.
2. Temperature records in northwestern mountainous region of Albania confirmed also a climate warming of 0.6 K during 20th century. At mountains regions, the warming has started about quarter of century later than at coastal plain area of western Albania.

3. Warming, mainly during the last quarter of the 20th century, is demonstrated also by meteorological data.
4. The rainfall regime changes have their consequences in the fresh water resources of the country, of surface's and underground waters.
5. Warming has caused its impact on country climate and ecosystems. There is observed a decreasing of the water resources of the country, and thermal stress in the wetlands, lagoons and lakes of Albania. on the erosion processes, and on the hydrographic regime of the Adriatic Sea. Impact it is observed first of all on the biodiversity. Coastline has an intensive change and continuously modifying its shape.
7. It is necessary to continued realizing, by a new project, of the analytical integrated studies of environmental impact of the global warming in Albanian territory and its consequences.

5. Acknowledgments

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Geothermal Energy Resources in Albania-Country Update Paper

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Keywords: direct use, heat flow, Albania

ABSTRACT

Resources of Geothermal Energy of low enthalpy in Albania, and the platform for their direct use are presented in the paper.

Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters are sulfate, sulfide, methane, and iodinate-bromide types. Thermal sources are located in three geothermal zones:

Kruja geothermal zone represents a zone with bigness geothermal resources, in carbonate reservoirs.

Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs.

Peshkopia geothermal zone at northeastern area of Albania. Several springs are located with disjunctive tectonics of the gypsum diapir.

The geothermal situation in Albania offers three directions for the exploitation of geothermal energy:

Firstly, the use of the ground heat flow for space heating and cooling, by borehole heat exchanger-heat pumps systems.

Secondly, thermal sources of low enthalpy are natural sources or wells in a wide territory of Albania. They represent the basis for a successful use of modern technologies for a *complex and cascade exploitation* of this energy:

1. SPA clinics for treatment of different diseases and hotels for eco-tourism.
2. The hot water for heating and sanitary waters of the SPA and hotels, greenhouses and aquaculture installations.
3. From thermal waters it is possible to extract chemical microelements.

Thirdly, the use of deep abandoned oil and gas wells as "Vertical Earth Heat Probe".

1. INTRODUCTION

Geothermal Resources of Albania evaluation and platform for their use, are based on the results of more than two decades of geothermal studies.

- Geothermal Atlas of Albania and Atlas of geothermal resources in Albania (2004), have been performed in framework of the of the Committee for Sciences and Technology of Albania projects, by agreement between the Faculty of Geology and Mining, and the Geophysical Institute, Czech Acad. Sci., Prague, European Commission- International Heat Flow Commission (Frashëri A. 1992, Frashëri A. et al. 1994, 1995, 1996). Geothermal team of the Faculty of Geology and Mining, have been worked for the UNDP-GEF/SGP Tirana Office project (2003), and "Geothermal Resources of Albania and platform for their use", in the framework of the National Program for Research and Developing, Natural Resources, 2003-2005 (Frashëri A. et al. 2003, 2004, 2005). Has been published in electronic format the "Atlas of Geothermal Resources in Albania (Frashëri A. et. al. 2004), and in hard format "Geothermal Atlas of Albania and platform for use of Earth's Heat" (2013).

Geothermal team from Faculty of Geology and Mining and Department of Energy of Faculty of Mechanical Engineering, during 2008 has worked for the Project: "Platform for integrated and cascade use of geothermal energy of low enthalpy in the framework of energetic balance of Albania", in the framework of the National Program for Research and Development, "Water and Energy" 2007-2009. Have been

published a monograph: "Space Heating/Cooling Borehole-Vertical Heat Exchanger-Heat Pump System" (Frashëri A. et. al. 2008). In same time, we had prepared three project ideas: "Geothermal Center for integrated and cascade direct use of geothermal energy of Kozani-8 well, near Elbasani City" (spa-hotel with hot pools, greenhouse and aquaculture instalations (spirulina and fish), Project idea for space heating of Korça University using borehole-vertical heat exchanger-heat pump system, and project idea for set up of the "Geo-Energy Ressouces Laboratory" in the Department of Energy Reasources, Faculty of Geology and Mining (Frashëri A. et al. 2008, 2009). "Geothermal Resources of Albania and platform for their use", monograph, was published during 2010 by Faculty of Geology and Mining, Faculty of Mechanical Engineering, Polytechnic University of Tirana (Frashëri A. & Kodhelaj N., 2010).

The Promemory "Earth Heat is an alternative, environ friendly renewable energy, which is necessary to use in Albania" has been addressed to the Albanian Government.

Periodically, results of the geothermal energy studies in Albania have been published and presented in International Symposiums, Conferences and Workshops.

In Albania there are many thermal water springs and wells of low enthalpy, with a temperature of up to 65.5°C, which indicates that there are possibilities for direct use of the geothermal energy. In Albania the new technologies of direct use of geothermal energy are either partly developed or remain still untouched. Integrated and cascade use of geothermal energy of low enthalpy will be represent an important direction for profitable investment. Exploitation of geothermal energy will have a direct impact in the development of the regions, by increasing their per capita income and at the same time ameliorating the standard of living of the people.

2. GEOLOGY BACKGROUND

The Albanides represent the main geological structures that lie on the territory of Albania. They are located between the Dinarides in the north and the Helenides in the south, and together they form the Dinaric Branch of Mediterranean Alpine Belt. Albanides are divided in two big peleogeographical zones: the Inner Albanides and the External Albanides. Korabi, Mirdita (ophiolitic belt), presents the Inner Albanides and Gashi zones. The Alps, the Krasta-Cukali, the Kruja, the Ionian zone, the Sazani zone and the Pre-Adriatic Depression present the External Albanides. Depression as a part of Albanian Sedimentary Basin continued towards the shelf of the Adriatic Sea. The geological cross-section of Albanian Sedimentary Basin is about 15 km thick and it continues also in the Adriatic Sea Shelf.

Ionian zone is developed as a large pelagic trough in the Upper Triassic. There, the evaporites of the Permian-Triassic are overlapped by a thick carbonate formation of the Upper Triassic-Eocene. The geological section on this carbonate formation is covered by Oligocene flysch, a flyschoid formation of the Aquitanian and by schilieres of the Burdigalian, Helvetian and particularly of Serravalian- Tortonian molasses. Burdigalian deposits are overlapped transgressively with an angular unconformity, anticline belts. The Tortonian Age deposits have filled the synclinal belts of Ionic and Kruja tectonic zones.

Miocene and Pliocene molasses of Peri-Adriatic Depression overlies the structures of northern part of the Ionian zone. The structure of Neogene molasses represents the upper tectonic stage of the structure of the Peri-Adriatic Depression.

In the over part of the section of Kruja zone, the carbonate neritic rocks of the Cretaceous-Paleogene age are overlying the Oligocene flysch of a thickness of 5 km.

The structures of the Albanides are typically Alpine ones. The SSE-NNW directions represent their general strike. The structures are asymmetrical and have a western vengeance. Recumbent, overthrusted and overtwisted structures are found, too. Generally, their western flanks are affected by disjunctive tectonic.

3. METHODS AND STUDY AREA

Geothermal studies carried out in Albania are oriented toward the study of the distribution of the geothermal field and the natural thermal water springs and wells. Geothermal studies were extended all over the country.

The temperatures have been measured and the geothermal gradient and the heat flow density at different depths have also been calculated (Frasheri et al. 1995). Temperature measurements were carried out both in 145 deep wells, in boreholes and in mines, at different hypsometric levels. The temperature in the wells was

recorded at regular intervals. It was measured by means of resistance and thermistor thermometers. The average absolute measurement error was 0.3°C. The measurements were carried out in a steady-state regime of the wells filled with mud or water. The recorded data were processed using the trend analysis of first and second degrees. The chemical composition of the waters was found. The output of the springs and wells and their hydrogeology was evaluated.

4. RESULTS

4.1. Geothermal Regime

The Geothermal Regime of the Albanides is conditioned by tectonics of the region, lithology of geological section, local thermal properties of the rocks and geological location (Frasheri A. 1992, Frasheri et al. 1994, 1995, 2004, 2010).

4.1.1. Temperature

The geothermal field is characterized by a relatively low value of temperature. The temperature at 100 meters depth varies from less than 10 to almost 20°C, with lowest values in the mountain regions. The temperature is 105.8°C at 6000 meters depth, in the central part of the Peri-Adriatic Depression. The isotherm runs parallel the Albanides strike (Fig. 1). Going deeper and deeper the zones of highest temperature move from southeast to northwest, towards the center of the Peri-Adriatic Depression and even further towards the northwestern coast. The temperatures in ophiolitic belt are higher than in sedimentary basin, at the same depth.

4.1.2. Geothermal Gradient

In the External Albanides the geothermal gradient is relatively higher (Fig.2).. The geothermal gradient displays the highest value of about 21.3 $mK.m^{-1}$ in the Pliocene clay section in the centre of Peri-Adriatic Depression. The largest gradients are detected in the anticline molasses structures of the center of Pre-Adriatic Depression (Fig. 5). The gradient decreases about 10-29% where the core of anticlines in Ionic zone contains limestone. The lowest values of 7-11 $mK.m^{-1}$ of the gradient are observed in the deep synclinal belts of Ionic and Kruja tectonic zones.

In the ophiolitic belt of the Mirdita tectonic zone, the geothermal gradient values increase up to 36 $mK.m^{-1}$ at northeastern and southeastern part of the Albania.

4.1.3. Heat Flow Density:

Regional pattern of heat flow density in Albanian territory is presented in the Heat Flow Map. There are observed two particularities of the scattering of the thermal field in Albanides (Fig. 3):

Firstly, maximal value of the heat flow is equal to 42 mW/m^2 in the center of Peri-Adriatic Depression of External Albanides. The 30 mW^{-2} value isotherm is open towards the Adriatic Sea Shelf. These phenomena have taken place owing to the great thickness of sedimentary crust, mainly carbonate one in this zone.

Secondly, in the ophiolitic belt at eastern part of Albania, the heat flow density values are up to 60 mW/m^2. The contours of Heat Flow Density give a clear configuration of ophiolitic belt. Radiogene heat generation of the ophiolites is very low. In these conditions, increasing of the heat flow in the ophiolitic belt, is linked with heat flow transmitting from the depth. The granites of the crystalline basement, with the radiogenic heat generation, represent the heat source.

4.2. Geothermal energy resources in Albania

Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters with a temperatures that reach values of up to 65.5°C are sulfate, sulfide, methane, and iodinate-bromide types (Frasheri A. et al. 1996, 2004, 2010) (Tab. 1, Fig.4). In many deep oil and gas wells there are thermal water fountain outputs with a temperature that varies from 32 to 65.5°C (Table 2, Fig. 3)

Albanian geothermal areas have different geologic and thermo-hydrogeological features. Thermal sources are located in three geothermal zones (fig. 4):

Kruja geothermal zone represents a zone with bigness geothermal resources. Kruja zone has a length of 180 km. Kruja Geothermal Zone is extended from Adriatic Sea at North and continues in South-Easter area of Albania and in Konitza area in Greece. Photo 1 shows Lëngarica - Përmet thermal springs at southern

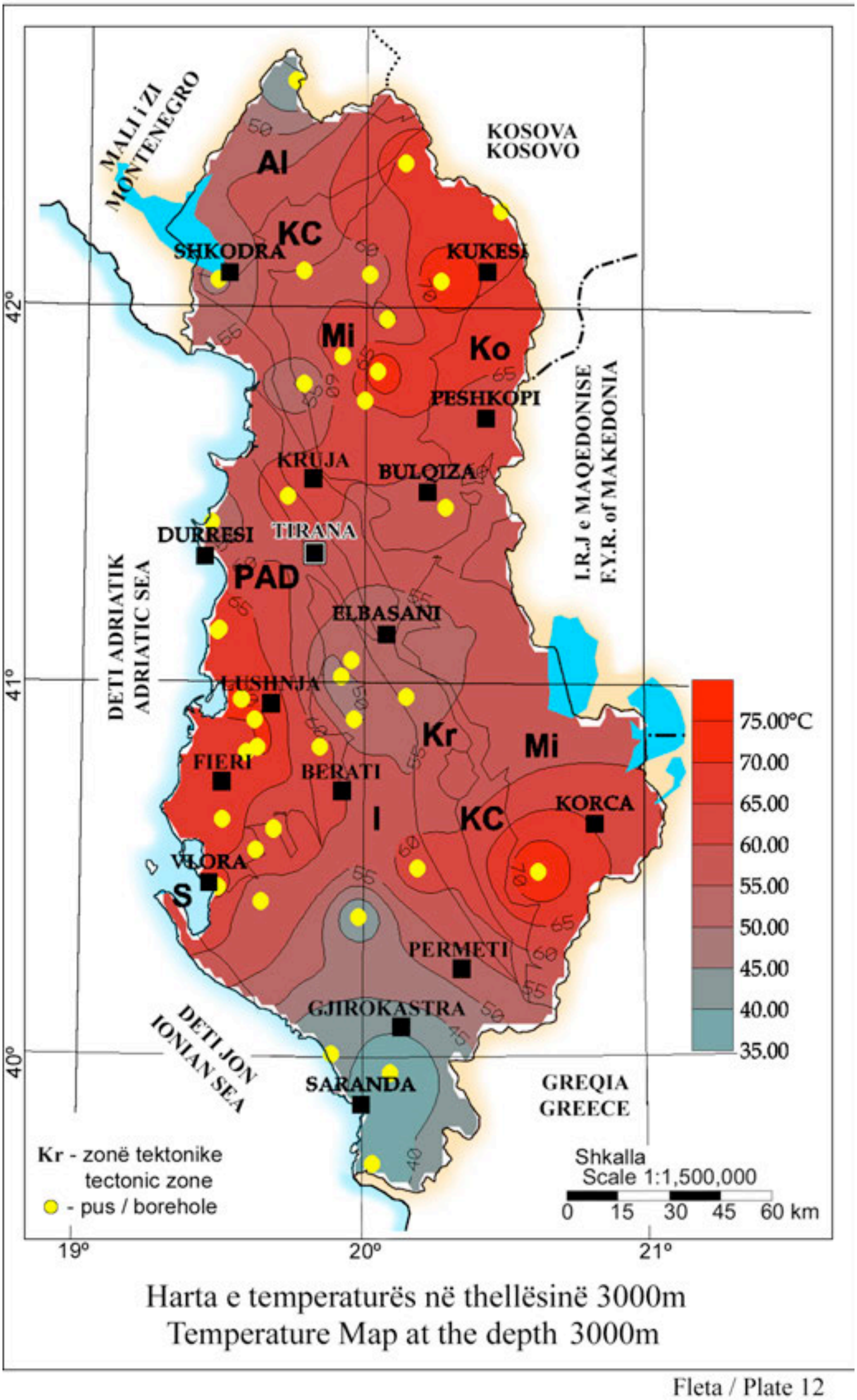


Fig. 1

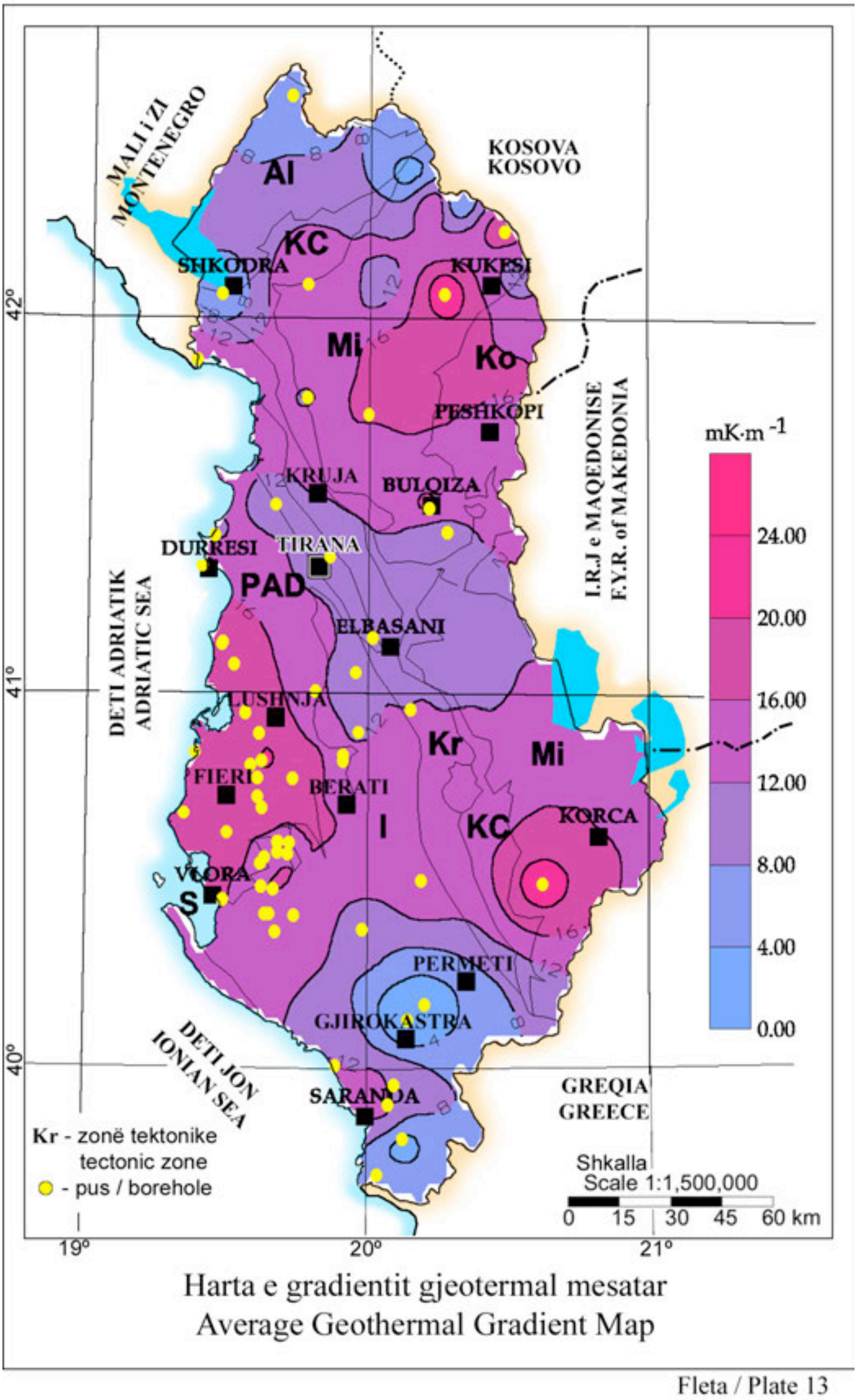
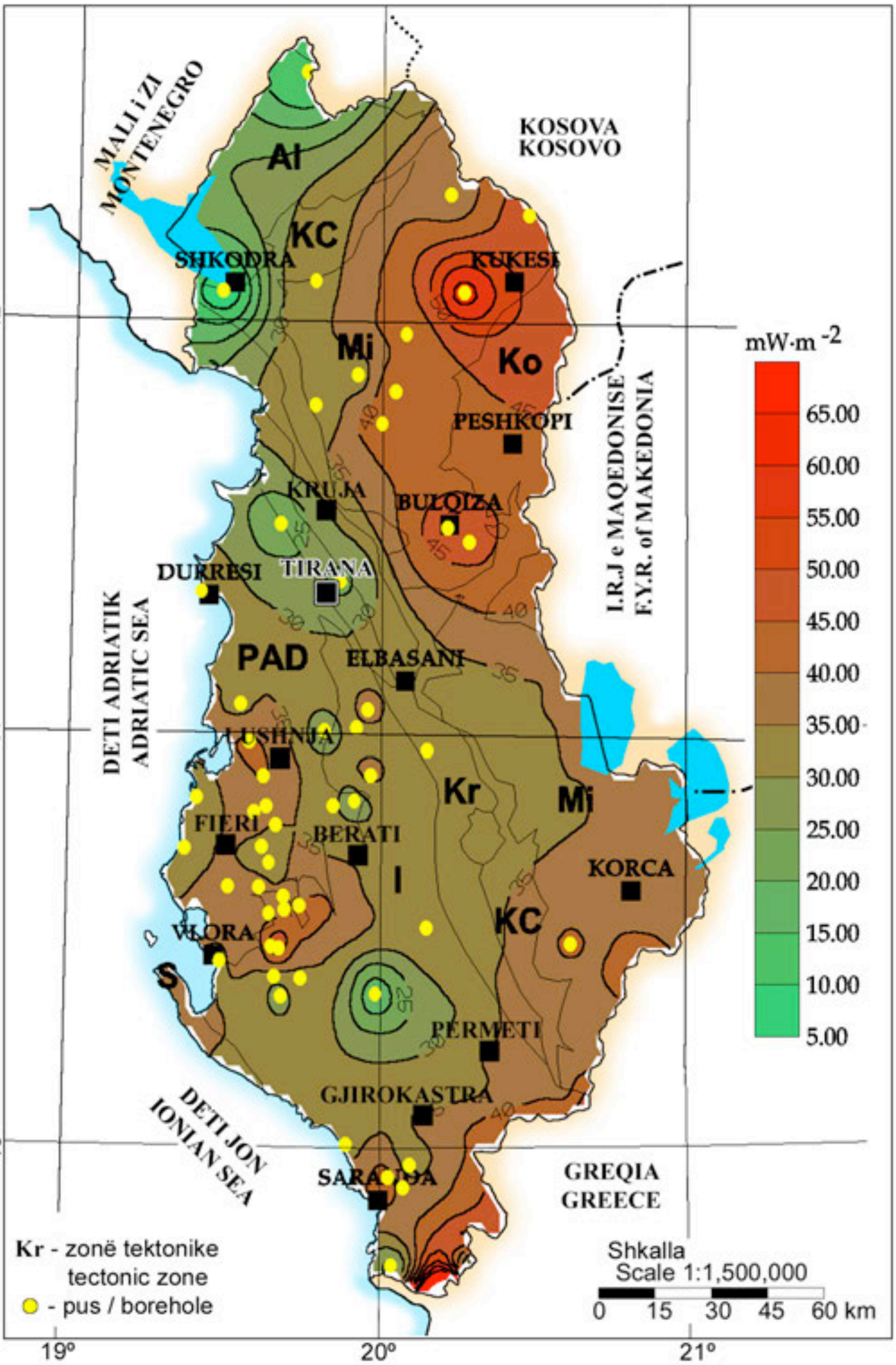

MALI i ZI
MONTENEGRO
KOSOVA
KOSOVO
SHKODRA
KUKESI
PESHKOPI
KRUJA
BULQIZA
DURRESI
TIRANA
ELBASANI
LUSHNJA
FIERI
BERATI
VLORA
KORCA
PERMETI
GJIROKASTRA
SARANDA
Al
KC
Mi
Ko
PAD
Kr
I
S
DETI ADRIATIK
ADRIATIC SEA
DETI JON
IONIAN SEA
I.R.J e MAQEDONISE
F.Y.R. of MAKEDONIA
GREQIA
GREECE
mK·m -1
24.00
20.00
16.00
12.00
8.00
4.00
0.00
Kr - zonë tektonike
tectonic zone
- pus / borehole
Shkalla
Scale 1:1,500,000
0 15 30 45 60 km
19°
20°
21°
42°
41°
40°
Harta e gradientit gjeotermal mesatar
Average Geothermal Gradient Map
Fleta / Plate 13

Fig. 2



Harta e dëndësisë së fluksit të nxehtësisë
Heat Flow Density Map

Fleta / Plate 16

Fig. 3

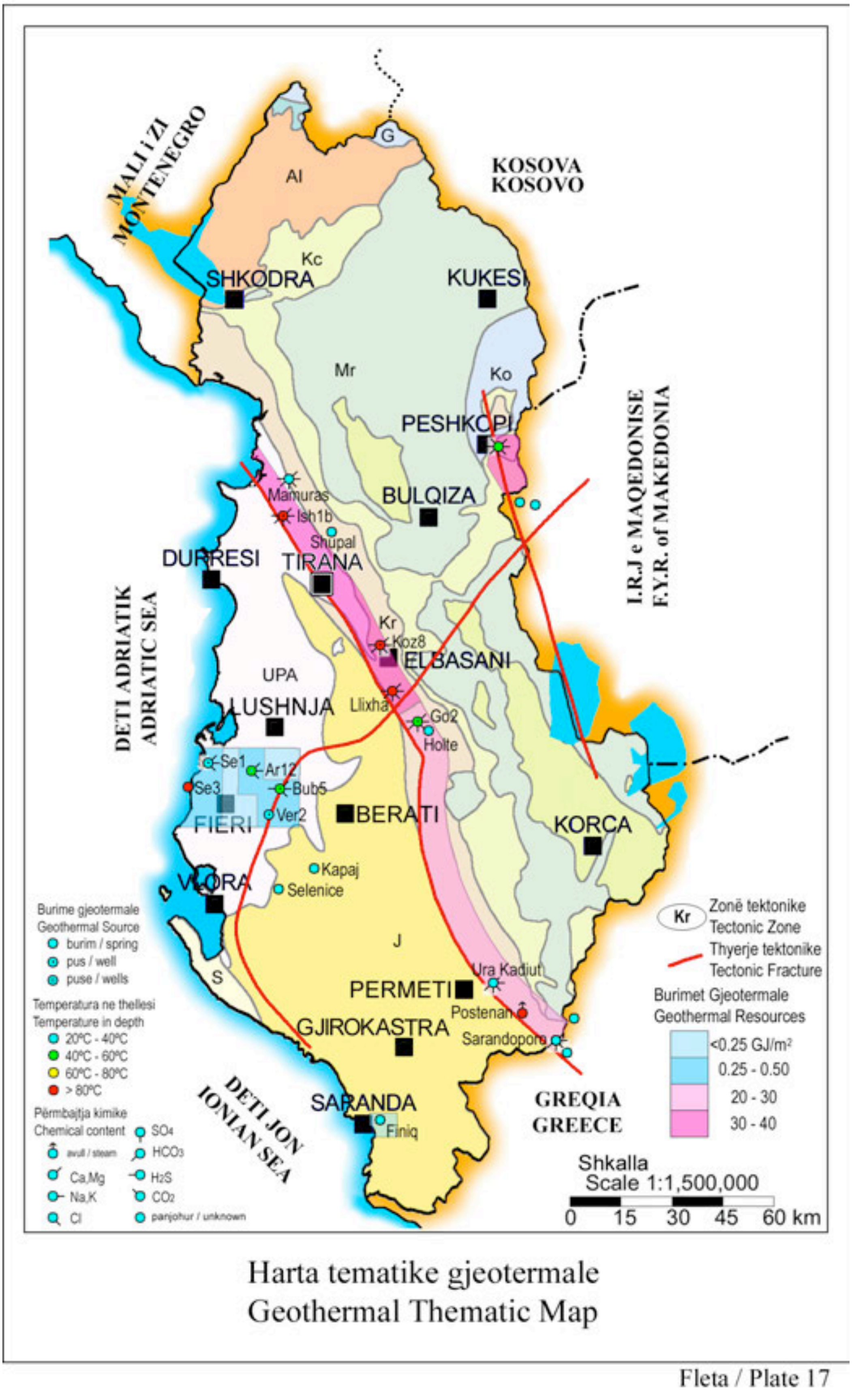

MALI i ZI
MONTENEGRO
KOSOVA
KOSOVO
SHKODRA
KUKESI
PESHKOPI
BULQIZA
DURRESI
TIRANA
ELBASANI
LUSHNJA
FIERI
BERATI
KORCA
VLORA
PERMETI
GJIROKASTRA
SARANDA
I.R.J e MAQEDONISE
F.Y.R. of MAKEDONIA
DETI ADRIATIK
ADRIATIC SEA
DETI JON
IONIAN SEA
GREQIA
GREECE
Burime gjeotermale
Geothermal Source
burim / spring
pus / well
puse / wells
Temperatura ne thellesi
Temperature in depth
20ºC - 40ºC
40ºC - 60ºC
60ºC - 80ºC
> 80ºC
Përmbajtja kimike
Chemical content
Zonë tektonike
Tectonic Zone
Thyerje tektonike
Tectonic Fracture
Burimet Gjeotermale
Geothermal Resources
<0.25 GJ/m²
0.25 - 0.50
20 - 30
30 - 40
Shkalla
Scale 1:1,500,000
0 15 30 45 60 km
Harta tematike gjeotermale
Geothermal Thematic Map
Fleta / Plate 17

Fig. 4

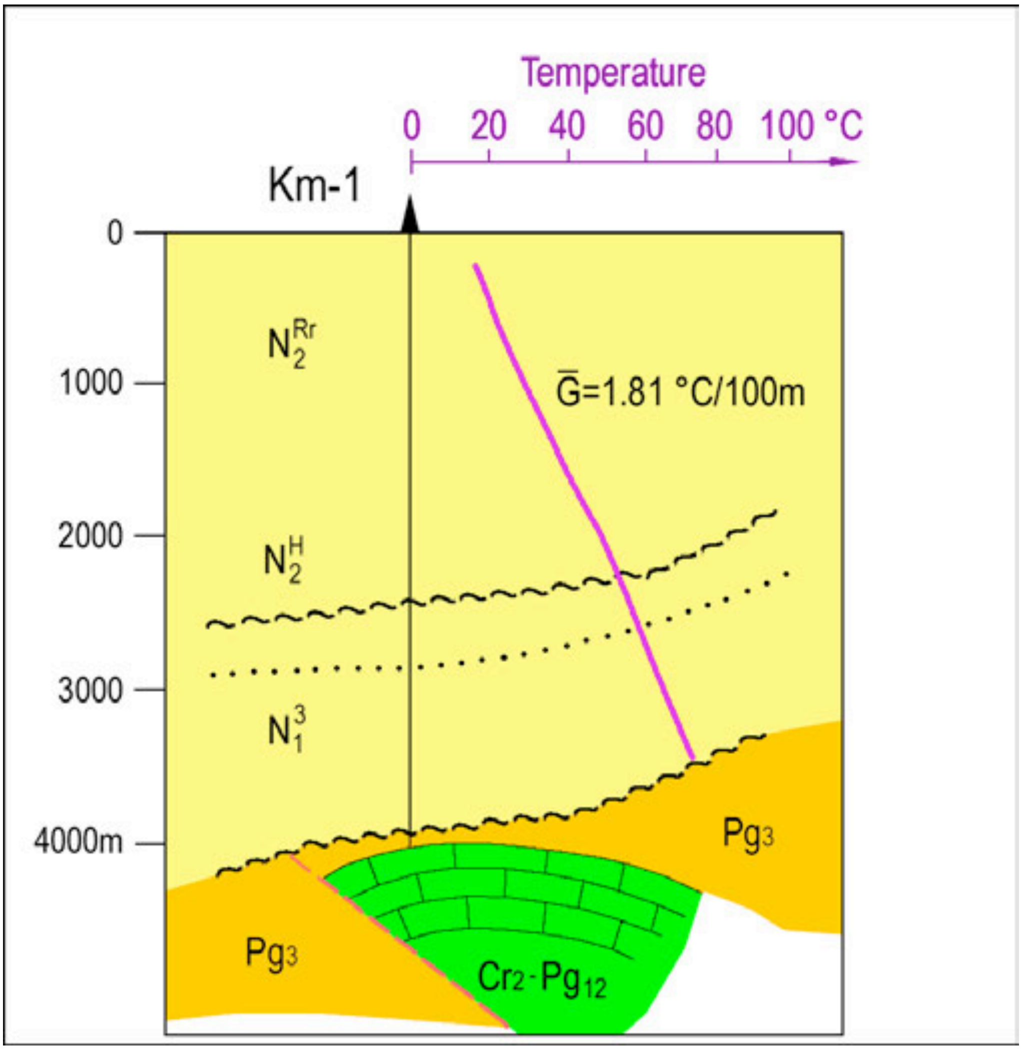


Fig. 5 - Geothermal Section Peri-Adriatic Depression

THERMAL WATER SPRINGS IN ALBANIA

Tab. 1

N° of Springs	Location	Temperature in °C	Salt in mg/l	Artesian Spring yield in l.s-1
1	Llixha Elbasan	60	6,3	15-18
2	Peshkopi	5-43	4,2	23
3	Lëngarica-Permet	6-31	1,65	>10
4	Sarandoporo-Leskovik	26,7	1,2	>10
5	Tervoll-Gramsh	24	2,5	>10
6	Mamurras-Tirane	21	5,4	>10
7	Steam Postenani springs			

. 1

THE OIL AND GAS WELLS THAT HAVE SELF-DISCHARGE OF THE THERMAL WATER

Tab. 2

N°	Well Name	Temperature in °C	Salt in $mg.l^{-1}$	Self-discharge in $l.sec^{-1}$
1	Kozani	65.5	4,6	10,4
2	Ishmi	64	15	4,4
3	Shupal-Tirana	29.5	1,6	1,6
4	Galigati	45-50	5,7	0,9
5	Bubullima	48-50	35	
6	Ardenica 3	38	38,2	15-18
7	Ardenica 12	32	53,6	5-18
8	Semani 1	35		5
	Semani 3	67	20,7	30
9	Verbasi	29.3	8,2	1-3

Photo 1. Langarica-Permeti thermal water springs

Albania. Identified resources in carbonate reservoirs in Albanian side are $5.9x10^8$-$5.1x10^9$ GJ. The most important resources, explored until now, are located in the Northern half of Kruja Geothermal Area, from Llixha-Elbasan in the South to Ishmi, in the North of Tirana. The values of specific reserves vary between 38.5-39.63 GJ/m^2.

Kruja geothermal area represents an anticline structure chain with carbonate core of Cretaceous-Eocene age. They are covered with Eocene- Oligocene flysch. Anticlines are linear with as length of 20-30 km. They are asymmetric and their western flanks are separated from disjunctive tectonics. Geothermal aquifer is represented by a karstified neritic carbonate formation with numerous fissures and micro fissures.

In the Ishmi area, Ishmi 1-b well has been drilled in 1994. It is situated in the top part of the limestone structure. It is located 20 km North- West of Tirana, in the plain area, near "Mother Theresa" Tirana airport. It meets limestone at 1300m of depth and goes through a carbonate coupe of 1016 m thickness.

Kozani 8 well has been drilled in 1989 (Photo 2). It is situated 35 km South- East of Tirana and 8 km North- West of Elbasani. It is situated on hills close to Tirana- Elbasani national road. It meets limestone at 1810m of depth and goes 10m deep in them.

Since the end of the drilling to this day hot water continues to fountain from Ishmi 1-b and Kozani 8 wells.

Elbasani Llixha watering place is about 12 km South of Elbasani. There are seven spring groups that extend like a belt with 320^o azimuth. All of them are connected with a the main regional disjunctive tectonics of Kruja zone. Thermal waters flow out through the contact of conglomerate layer with calcolistolith. In this area too, the reservoir is represented by the Llixha limestone structure. These springs have been known before Second World War.

Surface water temperatures in the Tirana-Elbasani zone vary from 60° to 65.5°. In the aquifer top in the well trunk of Kozani 8 temperature is 80°C. Hot water is mineralized, with a general mineralization of 4.6-19.3 g/l. Elbasani Nosi Llixha water has the following formula:

$$H_2S_{0.403}M_{7.1}\frac{Cl_{59}SO_{38}^{4}}{Na_{46}Ca_{35}}$$

Photo 2. Geothermal deep well Kozani - 8

Peshkopia geothermal zone is situated in the Northeast of Albania. Two kilometers East of Peshkopia some thermal springs are situated very close to each other. These thermal springs flow out on Banja river slope. These springs are linked with the disjunctive tectonic seismic-active zone Ohrid Lake-Debar, at periphery of gypsum diapir of Triassic age that has penetrated Eocene flysch which surround it like a ring. The occurrence of thermal waters is connected with the low circulation zone always under water pressure. They are of sulfate-calcium type, with a mineralization of up to 4.4 g/l, containing 50 mg/l H_2S. Their chemical formula is:

$$H_2S_{0.0495}M_{4.4}\frac{SO_{56}^{4}}{Ca_{65}}$$

Yield of some of the springs goes up to 14 l/sec. Water temperature is 43.5 °C.

Water temperature and large yield, stability, and also aquifer temperature of Peshkopia Geothermal Area similar are with those of Kruja Geothermal Area. For this reason geothermal resources of Peshkopia Area have been estimated to be similar to those of Tirana- Elbasani area.

Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs.

5. PLATFORM FOR THE DIRECT USE OF GEOTHERMAL ENERGY OF LOW ENTHALPY IN ALBANIA

The geothermal situation of low enthalpy in Albania offers three possibilities for the direct use of geothermal waters energy. Geothermal energy exploitation must be realized by integrated scheme of geothermal energy, heat pumps and solar energy, and cascade use of this energy (Frashëri A. 2001, Frasheri A. et al. 2003, 2004, 2008,2009, 2010).

Firstly, the Ground Heat can be use for space heating and cooling by Borehole Heat Exchanger-Geothermal Heat Pumps modern systems. At the present in Albania have been installed geothermal heating systems in six buildings in different cities: Tirana, Korça, Shkodra, Erseka.

Secondly, thermal sources of low enthalpy and of maximal temperature up to 65.5°C.

Thermal waters of springs and wells may be used in several ways:

1. Modern Wellness SPA for treatment and healing of different diseases, recreation, thermal physical and mental relaxation, with thermal bath and pools, sauna, massages, fitness and activities for development of eco-tourism. Such centers may attract a lot of clients not only from Albania, because the good curative properties of waters and springs are situated at nice places, near seaside, Gjinari Mountain or Ohrid Lake.

The oldest and important is Elbasani Llixha SPA is located in Central Albania. By national road communication, Llixha area is connected with Elbasani. These thermal springs from about 2000 years ago are known, near of the old road “Via Egnatia" that has passed from Durresi-Ohrid- to Constantinople. All seven groups of the springs in Llixha Elbasani and Kozani-8 well, near of Saint Vladimir Monastery at Elbasani, have the possibilities for modern complex exploitation. Ishmi 1/b geothermal well is located in beautiful Tirana field, near of Mother Theresa- Tirana Airport, near of the Adriatic coastline and Kruja - Skanderbeg Mountain.

Peshkopia SPA was constructed by modern concepts as balneological geothermal center. There are thermal pools, for medical treatment and recreation. Construction of the Peshkopia SPA must been good example for new SPA construction in Albania.

2. The hot water can be used also for heating of hotels, SPA and tourist centers, as well as for the preparation of sanitary hot water used there.

3. Near thermal water springs and wells it is possible to build the greenhouses for flowers and vegetables, asparagus cultivation, etc.

4. Aquaculture installations for cultivation of the micro-alga as spirulina etc. for alimentary industry, preparation of pomades, and fish cultivation will be other profitable activities.

5. From thermal mineral waters it is possible to extract very useful chemical microelements as iodine, bromine, chlorine etc. and other natural salts, so necessary for preparation of pomades for the treatment of many skin diseases as well as for beauty treatments. From these waters it is possible to extract sulphidric and carbonic gas.

6. Scientific research for study of the possibility of generating electricity from geothermal sources of low enthalpy, about 80^{o}C, as good local energy sources and provides a secure domestic energy supply with stable output.

Thirdly, the use of deep doublet abandoned oil and gas wells and single wells for geothermal energy, in the form of a "Vertical Earth Heat Probe". The geothermal gradient of the Albanian Sedimentary Basin has average values of about 18.7 $mK \cdot m^{-1}$. At 2 000 m depth the temperature reaches a value of about 48°C. In these single abandoned wells a closed circuit water system can be installed. Near of these wells, can be build greenhouses.

Actually in Albania is prepared a platform with scenarios for integrated and cascade use of the geothermal energy, in the framework of the National Program for Research and Development, Water and Energy (2007-2009). Based on complex analysis, for the best area selected according to the scenarios, a Feasibility Study is performed to analyze three components: energy supply, environmental impact and financial aspects, and to suggest the best solution of the innovative geothermal energy utilization technology applications in that area.

Consequently, the sources of low enthalpy geothermal energy in Albania, which are at the same time the sources of multi-element mineral waters, they represent the basis for a successful use of modern technologies for a *complex and cascade exploitation* of this environmental friendly renewable energy, achieving a economical effectiveness. Such developments are useful also for the creation of new working places and improvement of the level of life for local communities near thermal sources.

6. CONCLUSIONS

1. Albania has geothermal energy resources, which can be direct use as alternative, environmental friendly energy.

2. Resources of the geothermal energy in Albania are;

- Natural springs and deep wells with thermal water, of a temperature up to 65.5°C.
- Heat of subsurface ground, with an average temperature of 16.4^{o}C and depth Earth Heat Flow.

3. Construction of the space-heating system, based on direct use of ground heat, by using of the shallow borehole heat exchanger (BHE)-Heat Pumps systems, is actually most important direction of the use of geothermal energy.

7. ACKNOWLEDGMENTS

The authors express their thanks also to their colleagues of the Geothermal Team at the Faculty of Geology and Mining of the Polytechnic University of Tirana and of Geophysical Institute at Academy of Sciences of the Czech Republic in Prague, for their scientific collaboration and help in our studies of geothermal energy.

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ƚLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables Wind & Biomass		Tota	
	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	(
ɔperation December 9					1464	4362					1464	
er ɜtruction December 9			348	116	150	447					498	
ds committed, ɿnot yet under ɜtruction in ember 9			150	54	475	1415					625	
ɪl projected by 2015			498	170	1964	6224			880		2462	

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 2014

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating

2) 1F = Single Flash B = Binary (Ranking Cycle)
2F = Double Flash H = Hybrid (explain)
3F = Triple Flash O = Other (please specify)
D = Dry Steam

3) Data for 2014 if available, otherwise for 2013. Please specify which.

.

Locality	Power Plant Name	Year Comissioned	No Of Units	Status[1)]	Type of Units[2)]	Total Installed Capacity MWe	Total Running Capacity MWe	Annual Energy Produced 2014[3)] GWh/y	Total Under Constr. Or Planned MWe
	-	-	-	-	-	No	No	No	No
Total									

* Installed capacity is maximum gross output of the plant; running capacity is the actual gross being produced.

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2014 (other than heat pumps)

I = Industrial process heat
C = Air conditioning (cooling)
A = Agricultural drying (grain, fruit, vegetables)
F = Fish farming
K = Animal farming
S = Snow melting
H = Individual space heating (other than heat pumps)
D = District heating (other than heat pumps)
B = Bathing and swimming (including balneology)
G = Greenhouse and soil heating
O = Other (please specify by footnote)

Enthalpy information is given only if there is steam or two-phase flow

Capacity (MWt) = Max. flow rate (kg/s)[inlet temp. (^oC) - outlet temp. (^oC)] x 0.004184 (MW = 10^6 W)
or=Max flow rate (kg/s)x(inlet enthalpy (kJ/kg)-outlet enthalpy (kJ/kg))x0.001

Energy use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (^oC) - outlet temp. (^oC)] x 0.1319 (TJ = 10^{12} J)t
or=Ave flow rate (kg/s)x(inlet enthalpy (kJ/kg)-outlet enthalpy (kJ/kg))x0.03154

Capacity factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171
Note: the capacity factor must be less than or equal to 1.00 and is usually less,
Since projects do not operate at 100% of capacity all year.

Note: please report all numbers to three significant figures.

Locality	Type[1)]	Maximum Utilization					Capacity[3)]	Annual Utilization		
		Flow Rate	Temperature, (^oC)		Enthalpy[2)], (kJ/kg)			Ave Flow	Energy[4)]	Capacity Factot[5)]
		Kg/s	Inlet	Outlet	Inlet	Outlet	MWt	Kg/s	(TJ/yr)	
Llixh Elbasan	B	15	60	18			2.64	9	3.56	0.042
Peshkopi	B	16	43	18			1.49	6	2.4	0.051
Hydrat	B	18	55	18			2.78	3	1.19	0.013
Ishëm-Bilaj	B	3.5	64	18			0.61	2.5	0.99	0.019
Kozani-8	B	10.3	65.5	18			2.05	1	0.39	0.06
Bënjë	B	30-40	30.0	18			1.75			0.0
Sarandaporo	B	>10	26.7	18			0.36			0.0
Shupal	B	>10	29.5	18			0.048			0.0
TOTAL		**>112.8**	**373.7**	**144**			**11.728**	**21.5**	**8.48**	**0.131**

TABLE 4. GEOTHERMAL (GROUND-SOURCE) HEAT PUMPS AS OF 31 DECEMBER 2014

This table should report thermal energy used (i.e. energy removed from the ground or water) and report separately heat rejected to the ground or water in the cooling mode. Cooling energy numbers will be used to calculate carbon offsets.

Report the average ground temperature for ground-coupled units or average well water or lake water temperature for water-source heat pumps

Report type of installation as follows: V = vertical ground coupled (TJ = 10^{12} J)
H = horizontal ground coupled
W = water source (well or lake water)
O = others (please describe)

Report the COP = (output thermal energy/input energy of compressor) for your climate
Report the equivalent full load operating hours per year, or = capacity factor x 8760
Thermal energy (TJ/yr) = flow rate in loop (kg/s) x [(inlet temp. (°C) - outlet temp. (°C)] x 0.1319
or = rated output energy (kJ/hr) x [(COP - 1)/COP] x equivalent full load hours/yr

Locality	Ground or water temperature (°C[1])	Typical Heat Pump Rating Or Capacity (kW)	Number of Units	Type[2]	COP[3]	Heating Equivalent Full Load (Hr/yr[4])	Thermal Energy Used TJ/Yr	Cooling Energy Used TJ/Yr
Tirana (Twins Towers)	12	1200	100	W	2.5	2400	0.006	0.008
Tirana (Culture Palace)	12	500	1	W	4.06	880	0.001	0.009
Tirana (Residences)	12	2480	31	W	4.0	2400	0.0124	0.01656
Korçë (Kindergarten)	11	22.7	1	W	5.7	1300	0.000066	
Shkodër (Kindergarten)	12	80	2	W	5.0	2400	0.0004	0.00053
Shkodër (School)	12	180	2	W	4.1	2400	0.00081	0.001077
Ersekë (School)	10	34	1	W	4.7	1300	0.0001	
TOTAL						**13080**	**0.020776**	**0.01067**

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2014

1) Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (^oC) - outlet temp. (^oC)] x 0.004184
or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

2) Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (^oC) - outlet temp. (^oC)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg) x 0.03154

3) Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171 (MW = 10^6 W)
Note: the capacity factor must be less than or equal to 1.00 and is usually less,
since projects do not operate at 100% capacity all year

Use	Installed Capacity[1] MWt	Annual Energy Use[2] TJ/Yr=10^{12}J/Yr	Capacity Factor[3]
Individual Space Heating[4]			
District heating[4]			
Air Conditioning (Cooling)			
Greenhouse Heating			
Fish Farming			
Animal Farming			
Agricultural Drying[5]			
Individual Process Heat[6]			
Snow Melting			
Bathing and Swimming[7]	9.67	8.53	0.28
Other uses (specify)			
Subtotal	9.67	8.53	0.28
Geothermal Heat Pumps	4,446	o.020776	0.00174
TOTAL	14,016	8,550776	0.0192

4 Other than heat pumps
5 Includes drying or dehydration of grains, fryits and vegetables
6 Excludes agricultural drying and dehydration
7 Include balneology

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2005 TO DECEMBER 31, 2014 (excluding heat pump wells)

1) Include thermal gradient wells, but not ones less than 100 m deep

Purpose	Wellhead temperature	Number wells drilled				Total depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1]	alt					
Production	>150^oC					
	150-100 ^oC					
	>100 ^oC					
Injection	(all)					
TOTAL		N	N	N	N	

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES
(Restricted to personnel with University degrees)

(1) Government
(2) Public Utilities
3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Programs
(6) Private Industry

Year	Professional Person-Years of Effort					
2005	(1)	(2)	(3)	(4)	(5)	(6)
2006		5	9			7
2007		5	12		3	7
2008		2	11			8
2009		2	14			8
2014		2	18			8
		2	2			10
Total		18	64			48

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2014) US$

Period	Research & Development	Fiedel Development Including Production	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million USD	Million USD	Million USD	Million USD	%	%
1995-1999	0.099		1.525		94.0	6.0
2000-2004	0.046		1.732		97.5	2.5
2005-2009	0.06		2.071		97.2	2.8
2010-2014	0.14		5.375		97.4	2.6

DIRECT USE OF GROUND HEAT FOR SPACE HEATING AND COOLING,IN THE LOW ENTHALPY GEOTHERMAL ENERGY AREAS PRESENT A CONTRIBUTION IN COUNTRY ENERGY SYSTEM

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Abstract

Large numbers of geothermal energy of high and low enthalpy resources, a lot of mineral water sources represent the base for successfully application of modern technologies in Albania, to achieve economic effectiveness. There are many thermal springs and wells. Their water has temperatures that reach values of up to 65.5°C [Frashëri A. et al. 2003, 2010, 2013].

The geothermal situation of low enthalpy in Albania offers following directions for the exploitation of geothermal energy:

- Firstly, space heating and cooling,
- Secondly, integrated and cascade use of geothermal waters energy

In the paper a detailed analyze of the shallow ground heat resources in Albania, in particularly in Tirana city, and ways for direct use of this energy concretely for heating in Tirana is presented.

Geothermal space heating-cooling represent the most important direction is space heating and cooling. The Earth Heat can be use for space heating and cooling by modern systems Borehole Heat Exchanger-Geothermal Heat Pumps. Direct use of the ground heat by Borehole heat Exchanger-Geothermal Heat Pump for space heating and cooling, was programmed to develop in Albania. In the paper is presented a detailed analyze of the shallow ground heat resources in Albania, in particularly in Tirana city, and ways for direct use of this energy.

1. Introduction

Using renewable energy is the trend today in the advanced countries of the world, for several reasons: first to fulfill the energy requirements those are not completed by the fuel energy resources and secondly, are environmentally friendly energy. During the exploitation of renewable energies are released not create greenhouse gases and have not major impacts on the environment, and often affect ecosystems to improve.

It is therefore understandable that energy developments contemporary characterized today in advanced countries of the European Community, the USA, Japan etc., By use more and more renewable energy like water, the sun, wind, geothermal and biomass. Earth is a hot planet. Volcanoes lava and hot water more resources are the best witnesses of the Earth's heat in depth. Direct use of geothermal energy has an important place in the energy balance after hydropower. Geothermal energy is alternative energy, environmentally friendly, with integral and cascade using [Lund J.W. 1996, Rybach L. 2000]. It is also used directly in many areas of life and economic activity. Globally, in 2005 the installed capacity and direct geothermal energy used, had this structure [Lund J.W. 2005]:

Use	Instaled capacity (in MWt)	Used energy (in TJ/yr)
Heat pumps for space heaing and cooling	15,723	86,673
SPA	4,911	75,289
Direct space heating	4,158	52,868
Greenhouses heating	1,348	19,607
Aquaculture	616	1-,969
Industrial using	489	11,068
Cooking	338	1,885
Drying agricultural products	157	2,013
Etc.	86	1,045
TOTAL	**27,825**	261,418

The energetic situation in the Albania, the increased demand in premises, the gradual implementation of European standards of premises' heating, are all decisive factors raising the awareness in order to contribute in finding optimal solutions to this situation. Actually, the electric energy consummation for heating is 1 375 GWh/year, or 23.8 % of the total electric energy production in Albania (Fig. 1) (National Agency of Energy, Tirana, 2003). The situation becomes more problematic because the use of natural gas for heating emits large quantities of CO_2 in the atmosphere.

The Earth's heat is a great source of energy, renewable and friendly to the environment. Direct use of the ground heat by Borehole heat Exchanger-Geothermal Heat Pump represents a modern system for space heating and cooling [Curtis R. et al. 2005, Frashëri A. et al. 2013, Frashëri A. 2006, Rybach L 2005, Sanner B. 2004]. Two shallow geothermal sources exist: Ground heat through use of the ground-couplet (*closed loop*), and underground water system (*open loop*).

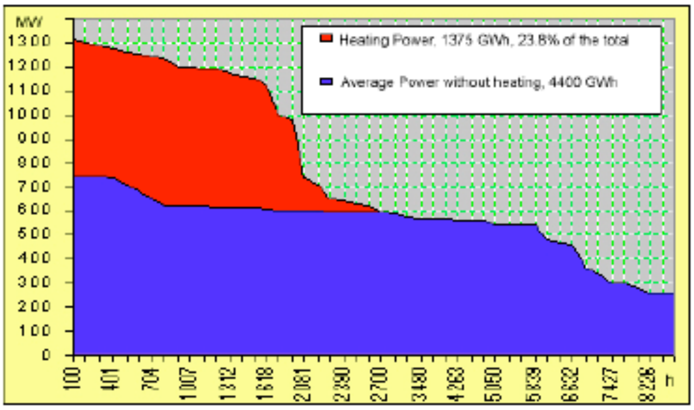


Fig. 1. Electrical power for heating and average power without heating in Albania.
(National Agency of Energy)

1. Earth's Heat is alternative energy, environmentally friendly, to be used in Albania

The real potential of geothermal energy can and should be used for economic purposes in Albania. Albanides, representing the geological structures in the Albanian territory, have geothermal flux able to be put in use (Fig. 2). In Albania there are also many sources and thermal water wells, geothermal energy of low entalpisë (Fig. 3). In Albania there are also many sources and wells that provide water temperature to 65.5 ° C and debits to 15 l / sec. These are a source of renewable energy, which should begin to be used in Bangladesh. To begin using this energy in Albania should:

First sensitize public opinion, public administration and Albanian investors for its effectiveness.

Secondly, currently in Albania have been performed geothermal, hydrogeological, hydrochemical and biological of thermal waters, and medical studies that should be used. Faculty of Geology and Mining, Polytechnic University of Tirana, published in electronic form "ATLAS OF GEOTHERMAL ENERGY RESOURCES IN ALBANIA" (2004), under the National Programme for Research and Development "Natural Assets", 2003-2005. Along with the Albanian Academy of Sciences published "ATLAS OF GEOTHERMAL ENERGY RESOURCES IN ALBANIA AND PLATFORM FOR THE EARTH HEAT USE " (2013).

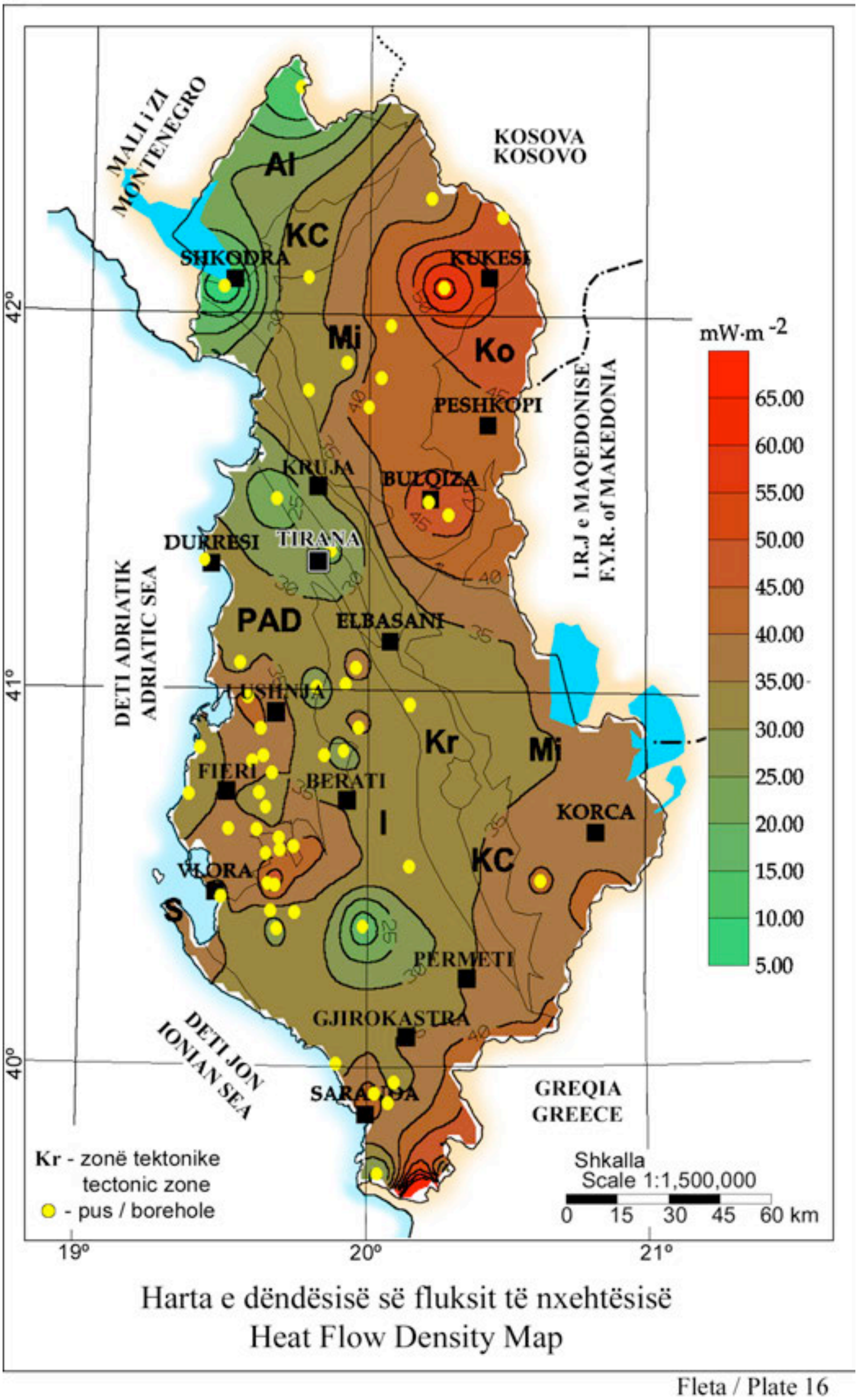


Fig. 2. Heat Flow Density Map of Albania.

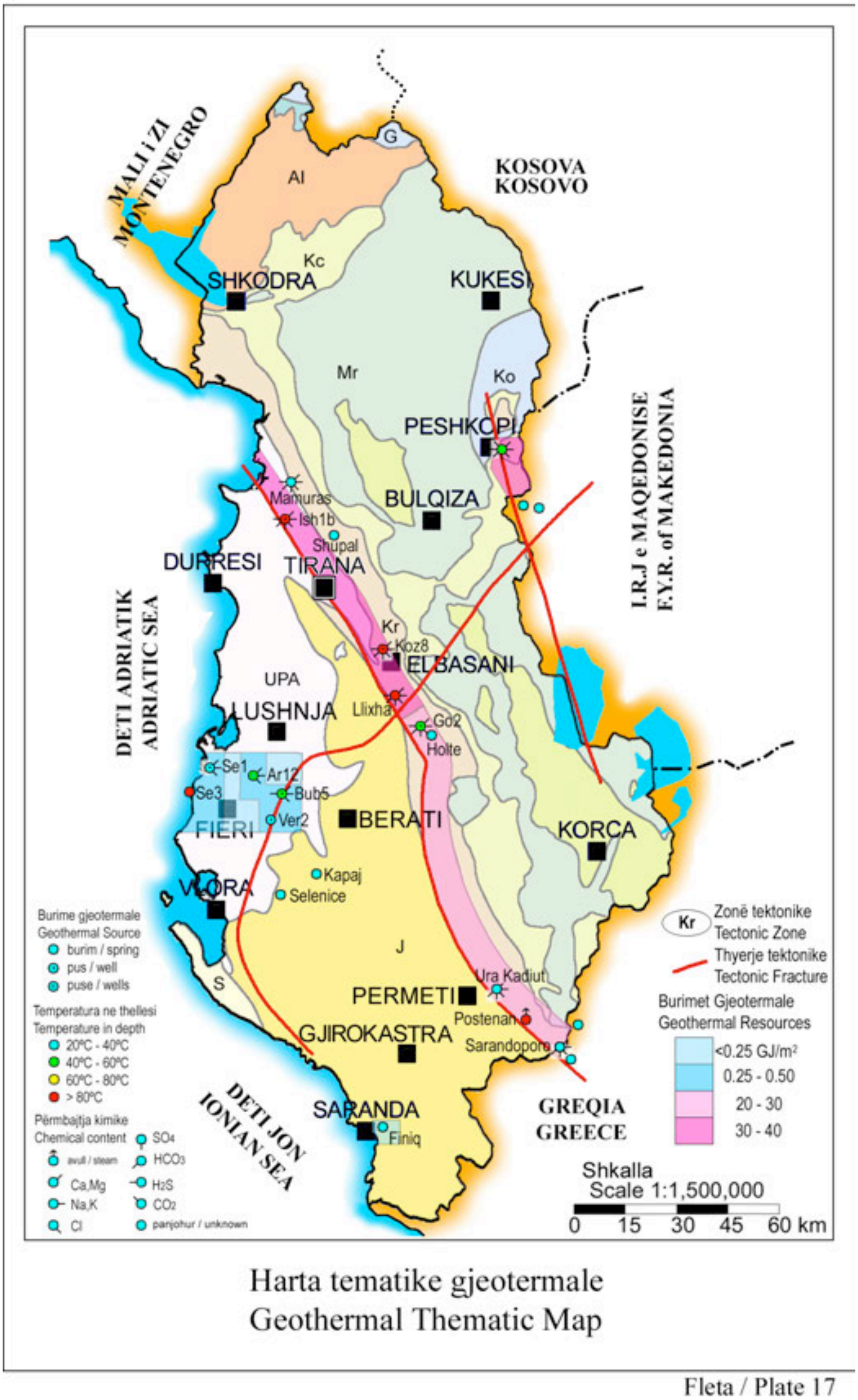


Fig. 3. Geothermal Thematic Map of Albania.

Based on the capacity of geothermal energy in Albania, as well as to experience the world of exploitation of this energy with modern technology and high economic effectivity, atract the attention of the Albanian business community that it is possible to create new profitable businesses in several directions:

1. Integral and cascade using geothermal waters heat. The use of thermal water sources or wells is facilitated by the fact that they are generally located in areas urban developed in Albania. So far only a few thermal water resources, as SPA: Lixha in Elbasan, in Bilaj Fushë Krujë, Peshkopi etc. used only for the treatment of various diseases. But the use of this energy in a primitive way, as a concept and as a development opportunity. This water can be used with high economic efficiency:

a) *Geothermal ecotourism*. Suffice it to mention that in Italy, visiting geothermal complex centers around 2.5 million tourists / year. Can build hotels with pools of warm water, the sauna, the halls and sport fields, with entertainment local, etc.

b) *Modern medical clinics*, to attract aldo the foreign patients who want to use the properties of rare curative thermominerl waters of our country.

c) *Greenhouse heating and acquaculture development* (rare and decorative fish, spirulina and other algaes, which produced the most expensive ointments for many diseases and cosmetics.

d) *Salts and utile microelements extraction*.

e) *Minerak waters bottling*.

2. **Space heating and cooling with modern borehole-vertical heat exchanger system-geothermal heat-pump (BHEGHP).** Usually, when it comes to geothermal energy, people only mean warm waters of sources. This is a part of the truth. But these waters are usually rare and few. What everywhere and in large quantities is the heat of subsurface soil layers from up at great depths. Thus, the main source of geothermal energy is the heat of these layers. This should be the main direction of the use of geothermal energy is the use of layers heat. These systems, for the same heating or cooling capacity, using geothermal energy, consuming on average more than 3 times less electricity compared to conditioners air-to-air heat pumps, which are used today in our country, or heating with these systems is about four times cheaper than heating with oil boiler.

Alike elsewhere in the world, in Albania the subsurface ground layers contain heat. This energy can be successfully exploited in heating the public premises (offices, schools, hospitals, libraries, theatres, airports etc.) as well as private premises (houses and apartment buildings), using the modern systems of Borehole-Heat Exchanger-Geothermal Heat Pumps. Actually, these modern systems in use, highly effective and with low consume of electric energy, technologically advanced and environmental friendly, are gaining huge popularity (Curtis, et al. 2005, Lund, 1996, Rybach, et al. 2000, Rybach, 2005, Sanner, 2004).

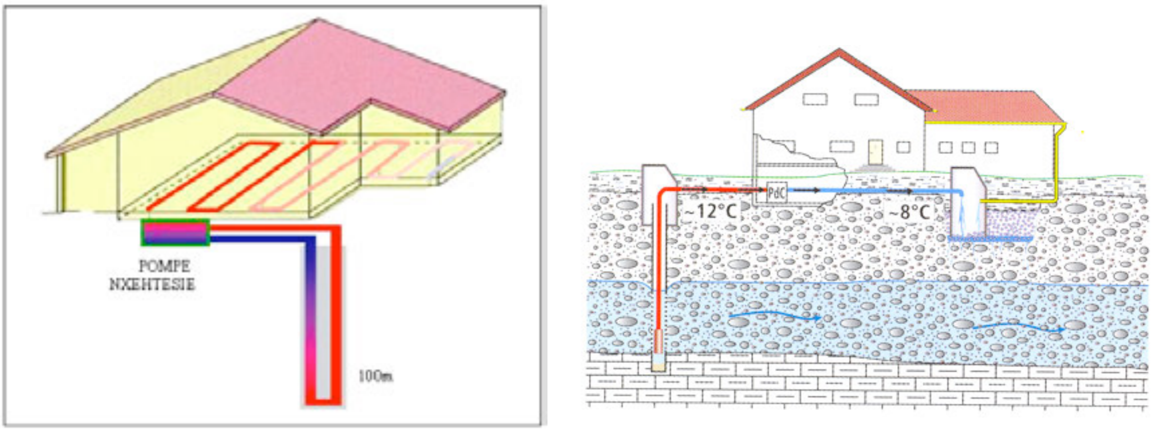
Two kind of technology is possible to applied (Frashëri A. et al. 2013, Lund J. W. 1996, Rybach L. et al. 2000):

Firstly, ground-source and Borehole heat Exchanger-Geothermal Heat Pump or ground-couplet (*closed loop*) (Fig. 4a),

Secondly: underground water, or lake and sea waters system – Geothermal Heat Pump (*open loop*) (Fig. 4b).

Heat from the earth strata obtained through heat exchangers, some types. A vertical heat exchanger (Fig. 3), coaxial or U-shaped, installed in 30-150 m deep drilling. Fluid circulating through the heat exchanger issued by layers of Earth. These systems are called heat swingers closed circuit. In Albania, where these layers have 5-20° C temperature can circulate water exchanger, because there is no risk of it freezing. Multiple changers, installed in Push battery is used to heat large buildings or public building block (Fig. 4) .

Currently these systems are more modern with higher economic efficiency and less consumption of electricity, with the most advanced environmentally friendly and are becoming more popular.



a) b)

Fig. 4. Borehole- Vertical Heat Exchanger- Geothermal Heat Pump System for space heating and cooling scheme, closet loop (a), open loop (b).

In 26 countries in Europe and the US, according to incomplete data for 2005 are mounted 900 thousand installations BHE-HP, in power 12 kW each, for heating and updating of houses-villas, but there are also thousands of installations on power up 500-1.500 kW heating institutions and municipal housing blocks (Ryback L. et al. World Geothermal Congress 2005). Installed capacity is 15,723 MWT and energy used 86.673 TJ / year (24.200 GWh). Germany currently has over 40 thousand installations. In 2005 installed geothermal heat pumps 6.799 and 1.526 alone air-conditioners with air pumps. Typical example is Switzerland, which has 25.000 installations, power pump from 19-40 kW, which use heat of subsurface layers of soil temperature 10^{o}C. Austria has 23.000 installations in Sweden 200.000, Denmark 43.000, France 40.000, in the USA 600.000 installations etc. [Curtis R. et al. 2005].

In order to make use of this renewable geothermal energy and environmental friendly ground heat for space heating and cooling in Albania, we have introduced the idea of building a demonstrative installation for heating and cooling purposes in Tirana [Frashëri et al. 2003]. The implementation of this project contributes in raising the awareness of the public administration, of the business and scientific communities, to make use of this economically optimal solution for heating and cooling of premises. The public administration should introduce the necessary tools and incentives for enabling the entering into the market of such modern and environmentally friendly systems. The business community should have in consideration and invest in installation of these Borehole-Heat Exchanger-Geothermal Heat Pumps, making way for new businesses. The universities should teach about these modern systems and insists on their applicability.

3. 2. Geothermal energy of the subsurface layers in Albania

Heat quantity, temperature at Earth surface, and geothermal gradient in shallow geological section, are conditioned by geographical location, geomorphological conditions (Earth surface dip and position in relation by Sun), ground and bedrocks lithology, specific heat and humidity, season and weather. According to the multi annual meteorological surveys result that in average is 140.000 calory/cm^2 heat from solar radiation of the ground during the summer at the plane areas of the Albania. Heat quantity reaches 120.000 calory.cm-2 at northeaster mountains regions [Gjoka L., 1990].

Thermal field distribution and geothermal gradient values in the ground at shallow geological section are conditioned that at the depth 100m the temperatures reaches from 16^{o}C up to 18,8^{o}C at plane areas in the Ionian tectonic zone and in Peri Adriatic Depression. The areas with a temperature between 18°C and 19°C are located at Kolonjë-Divjakë-Kryevidh, Vlorë and Sarandë- Delvinë zones. There are some particularities in the distribution of the temperature at the depth 100m (Fig. 5):

Temperature in subsurface ground at littoral area:
Minimal temperature is 16,60 ^{o}C

Maximal temperature is 18,80 ^{o}C
Average temperature is 17,80 ^{o}C

Temperature in subsurface ground at western plane-hilly area:
Minimal temperature is 17,15 ^{o}C
Maximal Temperature is 18,41 ^{o}C
Average Temperature is 18,0 ^{o}C

Temperature in subsurface ground at hillymountains regions:
Minimal temperature is 6,70 ^{o}C
Maximal temperature is 18,60 ^{o}C
Average temperature is 14,75 ^{o}C

In plane area of Albania, example in the Tirana field (Rinasi), the temperature is 15,5 ^{o}C, up to logging depth 31 m, in the Quaternary deposits (Fig. 6) [Frashëri et al. 2003]. According to the well-known data, the layers at the depth from 0-8- 10 m have a temperature, which is conditioned by solar radiation energy. During the winter, the temperature is lower than during the summer. Below, the ground temperature is constant during the year, because don't have the influence from solar radiation. Depth limit of the solar radiation influence zone is not unique. Lateral changes up to 0,5 ^{o}C are observed in the 500m distances, for the same time. These lateral changes are conditioned by lithology of the Quaternary loose deposits. The belt of the constant temperature continues up to the depth 50 m in the mountain regions of the Albania. Water temperature of the Quaternary sandstone layers is 15-16^{o}C.

According to the analyze of the geothermal regime of the shallow geological section is concluded that is possible to use the ground heat for the space heating and cooling, applied modern Borehole Heat Exchanger – Geothermal Heat Pump. Ground geothermal energy has heated the underground water reservoir. In Tirana underground water basin are following temperatures: Water temperature of the Quaternary gravel layer is 14-15 ^{o}C, Consequently, concluded that water of the Tirana underground basin can be a heat source for the geothermal pumps.

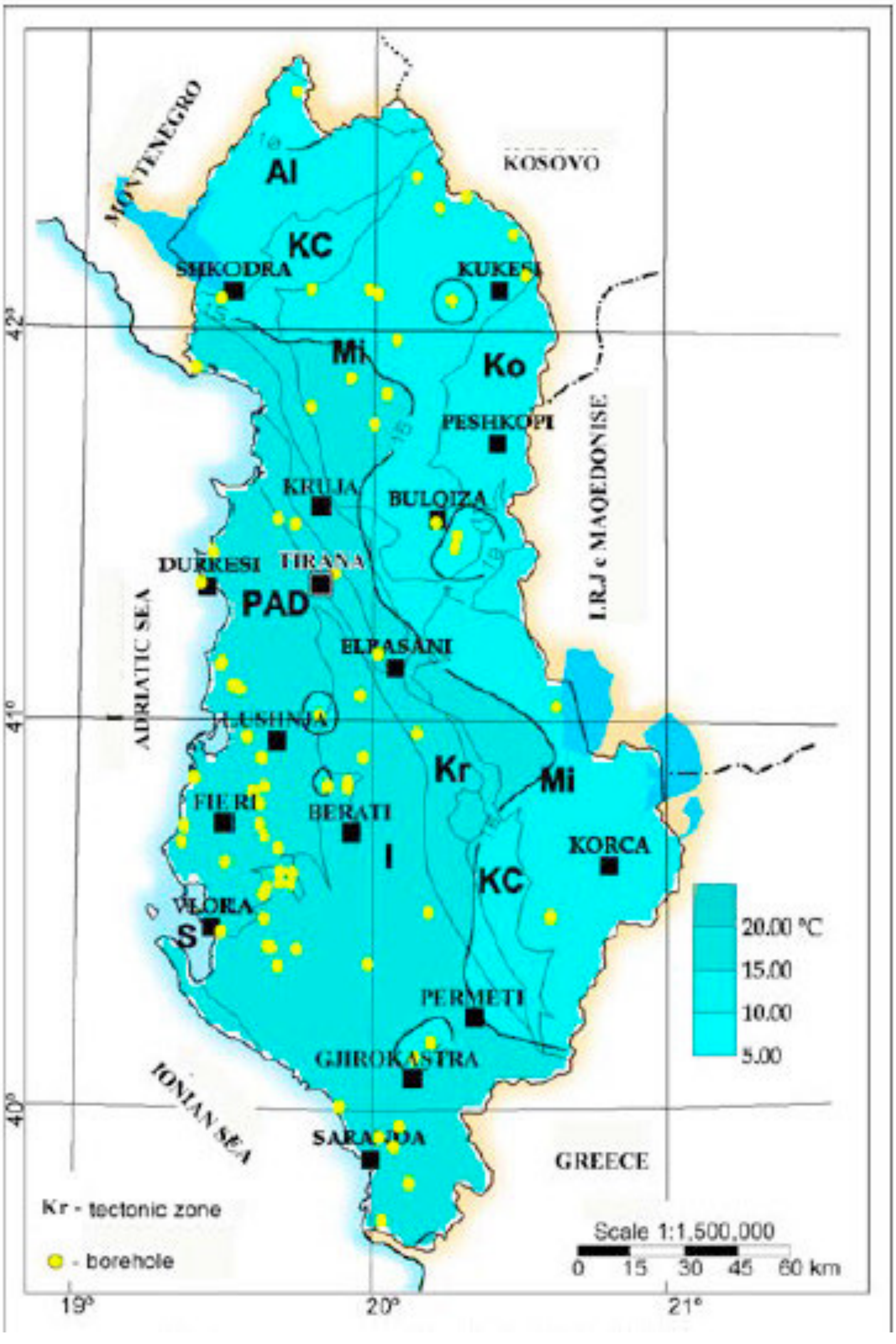


Fig. 5. Temperature Map of Albania, at the depth 100 m.

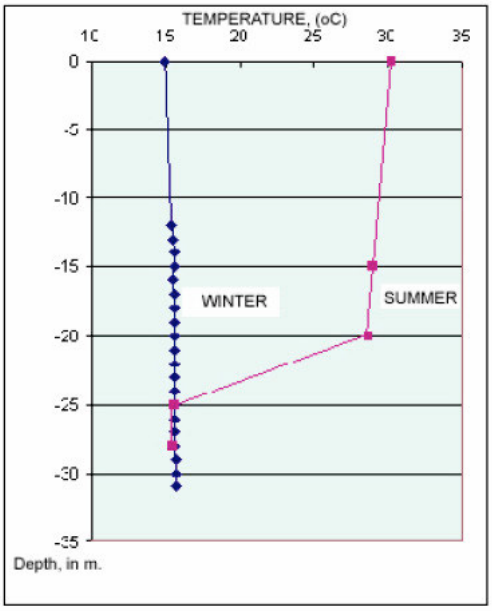


Fig. 6. Thermolog of the Rinasi borehole

4. Economic evaluation of the proposed scheme

Heating of the Hotel:

Total heated surface, for three-floors: 610 m^2
Heating system: Borehole-Heat Pump-Radiators
Heating capacity 68,5 KW
Heating period 1.836 hours

Heating system, there are analyzed three variants:
a) Borehole-Geothermal Heat Pump
b) Oil Fired Boiler
c) Air-Air Conditioners

Installed cost for Borehole-Geothermal Heat Pump System:

Geothermal Heat Pump, with a heating capacity 68,5 kW, 19.840 USD/unit
Installation of the Geothermal Heat Pump System 1.800 USD
Heating and cooling equipment (radiators, pipes etc.) and its installation in the room 16,7 USD/m^3,
for 1830 m^3 for all building 25.860 USD
Providing water to the geothermal heating pump and re-injection of water in the collector after the use (Shallow boreholes, circulating pump, pipeline), according to the price index in Tirana: 7.500 USD.
Total 55.000 USD **90,16** USD/m^2

Preliminary installed cost for three systems:
a) Borehole-Geothermal heat pump 55.000 USD
b) Borehole-Vert. Heat Exchanger-heat ump 87.630 USD
c) Oil Fired Boiler 26.880 USD
d) Air-air conditioners, type “General” 19.970 USD

Preliminary installed cost for square meters of heated surface:
a) Borehole-Geothermal Heat Pump 90,16 USD/m2
b) Borehole-Vertical Heat Exchanger-Heat Pump 144,17 USD/m2
c) Oil Fired Boiler 57,04 USD/m2
d) Air-Air Conditioners, type “General” 33,28 USD/m2

Preliminary electric energy or fuel yearly consumption (operating) and cost:

a) Borehole-Geothermal Heat Pump	33.304 KW/y	4.332 USD/y
b) Oil Fired Boiler	12.282 Lit. oil/y	15.337 USD/y
c) Air-air conditioners	93.636 KW/y	12.179 USD/y

Preliminary total yearly heating energy cost (installed and operating cost): -

	First year	*Second year*
a) Borehole-Geothermal Heat Pump	866,74	63,23- USD/kW
b) Borehole-Vert. Heat Exchanger-Heat Pump	1.342,50	63,23
c) Oil Fired Boiler	728,42	177,80
d) Air-air conditioners	469,49	261,48

a) Borehole-Geothermal Heat Pump	97,33	7,10 - USD/m^2
b) Borehole-Vert. Heat Exchanger-Heat Pump	150,76	7,10
c) Oil Fired Boiler	81,79	19,64
d) Air-Air Conditioners	52,72	15,60
e) Electrical Radiators	29,36	29,36

Electric energy or fuel yearly consumption (operating) cost total yearly heating energy cost (Installed and operating cost) during 10 years of the different heating system using in the fig. 7 and 8 are presented.

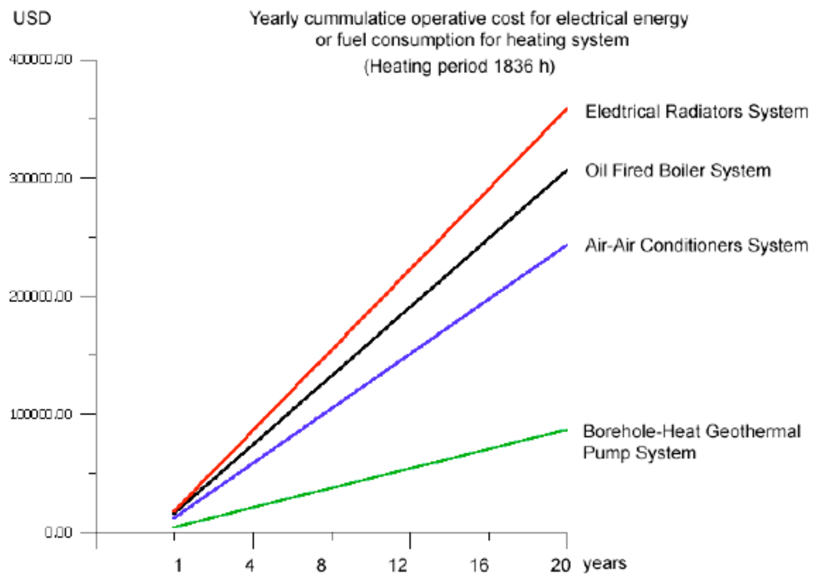


Fig. 6

Fig. 7. Yearly accumulative operative cost for electrical energy and fuel consumption for space heating system (heating period 1.836 h)

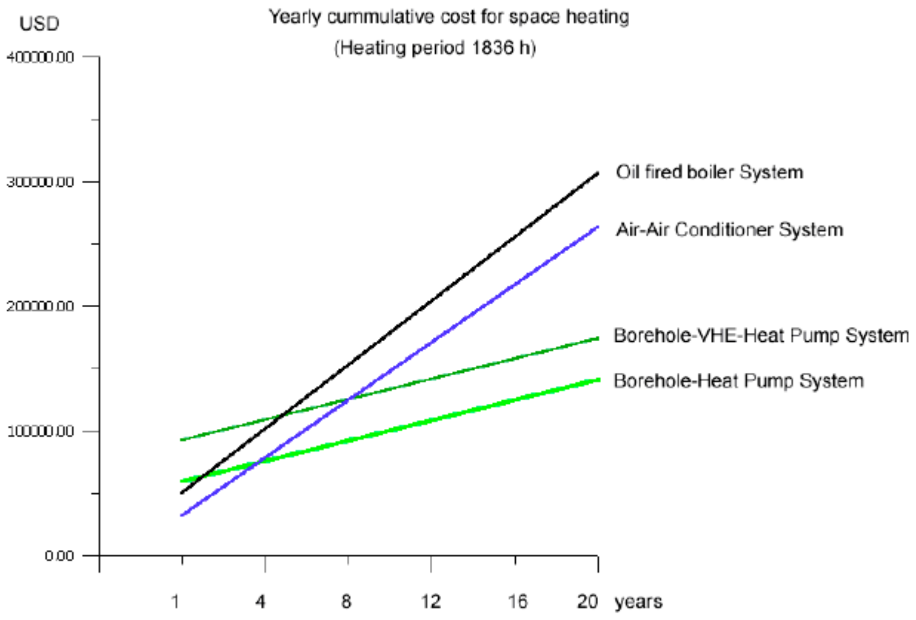


Fig. 7

Fig. 8. Yearly accumulative cost for space heating (heating period 1.836 h)

Installed cost for geothermal system unit result 90- 144 USD/m^2, and 803-1279 USD/kW, depended from the heat source. Borehole-Vertical Heat Exchanger-Geothermal Heat Pump System has the higher cost. Lower costs have Borehole-Geothermal Heat Pumps systems, with shallow underground water heat source.

After the data presented in the fig. 7 and 8, results that installed cost for the geothermal systems is 2.0-2.8 much higher than for the boiler or air-air conditioner systems.

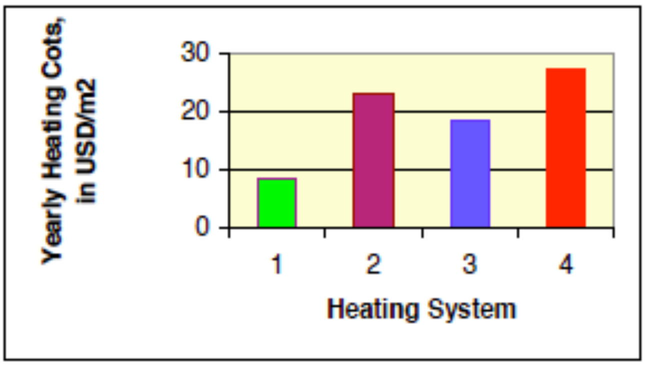
Payback period for the installed cost for the “Borehole-Geothermal Heat Pump” System will be 2 years, covered only by expenses savings for boiler fuel, and 4 years, covered only by expenses savings for air-air conditioners.

Payback period for the intalled cost for the “Borehole-Vertical Heat Exchanger-Geothermal Heat Pump” System will be 4 years, covered only by expenses savings for boiler fuel, and 8 years, covered only by expenses savings for air-air conditioners.

In fig 9 is presented the graphic of the cost of space heating for different heating systems (in USD/kW). According to this graphic results that geothermal heating and cooling system is more economic system.

Fig. 9. Cost of space heating for different heating systems (in USD/m2).

1- Geothermal System;
2- Oil Fired Boiler System;
3- Air-Air Conditioner System;
4- Electric Radiator System.



4. Call for investment

The heating problem and its economic solution is an important task, taking into consideration the current severe energetic crises. One of the ways out is the use of geothermal energy. In Albania there are many

high-rise building, which are still projected to include oil or gas fired boiler systems, as well as with air conditioning units. Air conditioning units heat all public institutions. The hospitals, dorms, hotels are heated by oil and gas fired boilers. It is the ripe time to move out of such practices, which do not provide for long term sustainable solutions to the heating and cooling problems in Albania. It is the right time to introduce systems using renewable energy sources such as the geothermal energy.

In order to introduce the system of geothermal energy, a renewable and environmental friendly energy source, we propose to build a demonstrative installation, heating and cooling any given building in Tirana.

Implementing this project will provide for an optimal and economically efficient solution, which will be of benefit to the public administration, business community, as well as to the technical and scientific community. It will pave the way for a more economically efficient solution to heat and cool buildings. Optimally the government will promote and stimulate the introduction of such systems in Albania. In addition there are economic incentives for the business community to invest in this new venture, which we believe is the economical solution also for our country.

4.1. Project goal and objectives

4.1.1. Project goal:

a) Design and construction of the demonstrative space heating system, with underground waters or shallow ground heating sources.

b) Albanian investors and communities sensitizing for high economic effectiveness of integrated and cascade use of environmental friendly geothermal energy in Albania.

4.1.2. Objectives:

1. Design and construction of the demonstrative space heating system, in one of a new constructed or existing building, with oil fired boiler heating system..
2. Construction of the demonstrative space heating system.
3. Knowledge dissemination: Workshops, seminars, TV emissions, lectures in the Universities: "Space heating and cooling direct using of the environmental friendly geothermal energy, in the framework of the renewable energies use, to improve the country energy balance and an important profitable investment present"

4.1.3. Necessary Investment

It is necessary to match the installation of the demonstrative geothermal system to the size of the building. It is also necessary to have a building, which is heated by a boiler. Initially it would be most suitable to build an installation, which will use underground water as the heat source. This will provide for a lower cost.

Based on feasibility study, the installed cost of geothermal heating system, with underground waters heat source will be 90- 144 USD/m^2. Direct use of the Geothermal Energy in Albania must start as soon as possible, first of all for the solving of the space heating and cooling. Will be high economic effectiveness investment.

Economical considerations (Curtis, et al. 2005, Lund, 1996, Rybach, et al. 2000, Rybach, 2005, Sanner, 2004). Actually, the cost of installing the Borehole-Heat Exchanger-Geothermal Heat Pump is higher than the conventional fuel installations. Nonetheless, the annual cost of "fuel" of the Borehole-Heat Exchanger-Geothermal Heat Pump (Electric energy for the heat pump and circulating pump) are considerably lower than the fuel of the conventional heating by gas. For the coefficient of performance 3, is saved up to 66% of the electrical energy. Consequently, the payback of the Borehole-Heat Exchanger-Geothermal Heat Pump system is shorter than the durability of using the other heating system.

Environmental considerations. Borehole-Heat Exchanger-Geothermal Heat Pump is an environmental system that does not emits CO_2 ("greenhouse effect"), therefore the proprietor avoid paying the tax on emittance of CO_2 gas, which is under discussion in the countries of the European Community. Governmental support. Japan using the geothermal energy of subsurface ground layers saves up to 40%

of the total energy (Japan Times, Jan. 21, 2003). The expenses necessary to carry out this project will be paid within 10 years. Two thirds of the building costs, valued up to 10 million yen for the government and local authorities support each installation. The Japanese government has invested 200 USD for every kW of the Heat Geothermal Pump, with an upper limit of 5 200 USD.

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Geothermal Energy Use, Country Update for Albania

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Keywords: direct use, heat flow, Albania

ABSTRACT

Resources of Geothermal Energy of low enthalpy in Albania, and the platform for their direct use are presented in the paper.

Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters are sulfate, sulfide, methane, and iodinate-bromide types. Thermal sources are located in three geothermal zones:

Kruja geothermal zone represents a zone with bigness geothermal resources, in carbonate reservoirs.

Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs.

Peshkopia geothermal zone at northeastern area of Albania. Several springs are located with disjunctive tectonics of the gypsum diapir.

The geothermal situation in Albania offers three directions for the exploitation of geothermal energy:

Firstly, the use of the ground heat flow for space heating and cooling, by borehole heat exchanger-heat pumps systems.

Secondly, thermal sources of low enthalpy are natural sources or wells in a wide territory of Albania. They represent the basis for a successful use of modern technologies for a *complex and cascade exploitation* of this energy:

1. SPA clinics for treatment of different diseases and hotels for eco-tourism.
2. The hot water for heating and sanitary waters of the SPA and hotels, greenhouses and aquaculture installations.
3. From thermal waters it is possible to extract chemical microelements.

Thirdly, the use of deep abandoned oil and gas wells as "Vertical Earth Heat Probe".

1. INTRODUCTION

Geothermal Resources of Albania evaluation and platform for their use, are based on the results of more than two decades of geothermal studies.

- Geothermal Atlas of Albania and Atlas of geothermal resources in Albania (2004), have been performed in framework of the of the Committee for Sciences and Technology of Albania projects, by agreement between the Faculty of Geology and Mining, and the Geophysical Institute, Czech Acad. Sci., Prague, European Commission- International Heat Flow Commission (Frashëri A. 1992, Frashëri A. et al. 1994, 1995, 1996). Geothermal team of the Faculty of Geology and Mining, have been worked for the UNDP-GEF/SGP Tirana Office project (2003), and "Geothermal Resources of Albania and platform for their use", in the framework of the National Program for Research and Developing, Natural Resources, 2003-2005 (Frashëri A. et al. 2003, 2004, 2005). Has been published in electronic format the "Atlas of Geothermal Resources in Albania (Frashëri A. et. al. 2004), and in hard format "Geothermal Atlas of Albania and platform for use of Earth's Heat" (2013).

Geothermal team from Faculty of Geology and Mining and Department of Energy of Faculty of Mechanical Engineering, during 2008 has worked for the Project: "Platform for integrated and cascade use of geothermal energy of low enthalpy in the framework of energetic balance of Albania", in the framework of the National Program for Research and Development, "Water and Energy" 2007-2009. Have been published a monograph: "Space Heating/Cooling Borehole-Vertical Heat Exchanger-Heat Pump System" (Frashëri A. et. al. 2008). In same time, we had prepared three project ideas: "Geothermal Center for integrated and cascade direct use of geothermal energy of Kozani-8 well, near Elbasani City" (spa-hotel with hot pools, greenhouse and aquaculture instalations (spirulina and fish), Project idea for space heating of Korça University using borehole-vertical heat exchanger-heat pump system, and project idea for

set up of the "Geo-Energy Ressouces Laboratory" in the Department of Energy Reasources, Faculty of Geology and Mining (Frashëri A. et al. 2008, 2009). "Geothermal Resources of Albania and platform for their use", monograph, was published during 2010 by Faculty of Geology and Mining, Faculty of Mechanical Engineering, Polytechnic University of Tirana (Frashëri A. & Kodhelaj N., 2010).

The Promemory "Earth Heat is an alternative, environ friendly renewable energy, which is necessary to use in Albania" has been addressed to the Albanian Government.

Periodically, results of the geothermal energy studies in Albania have been published and presented in International Symposiums, Conferences and Workshops.

In Albania there are many thermal water springs and wells of low enthalpy, with a temperature of up to 65.5°C, which indicates that there are possibilities for direct use of the geothermal energy. In Albania the new technologies of direct use of geothermal energy are either partly developed or remain still untouched. Integrated and cascade use of geothermal energy of low enthalpy will be represent an important direction for profitable investment. Exploitation of geothermal energy will have a direct impact in the development of the regions, by increasing their per capita income and at the same time ameliorating the standard of living of the people.

2. GEOLOGY BACKGROUND

The Albanides represent the main geological structures that lie on the territory of Albania. They are located between the Dinarides in the north and the Helenides in the south, and together they form the Dinaric Branch of Mediterranean Alpine Belt. Albanides are divided in two big peleogeographical zones: the Inner Albanides and the External Albanides. Korabi, Mirdita (ophiolitic belt), presents the Inner Albanides and Gashi zones. The Alps, the Krasta-Cukali, the Kruja, the Ionian zone, the Sazani zone and the Pre-Adriatic Depression present the External Albanides. Depression as a part of Albanian Sedimentary Basin continued towards the shelf of the Adriatic Sea. The geological cross-section of Albanian Sedimentary Basin is about 15 km thick and it continues also in the Adriatic Sea Shelf.

Ionian zone is developed as a large pelagic trough in the Upper Triassic. There, the evaporites of the Permian-Triassic are overlapped by a thick carbonate formation of the Upper Triassic-Eocene. The geological section on this carbonate formation is covered by Oligocene flysch, a flyschoid formation of the Aquitanian and by schilieres of the Burdigalian, Helvetian and particularly of Serravalian- Tortonian molasses. Burdigalian deposits are overlapped transgressively with an angular unconformity, anticline belts. The Tortonian Age deposits have filled the synclinal belts of Ionic and Kruja tectonic zones.

Miocene and Pliocene molasses of Peri-Adriatic Depression overlies the structures of northern part of the Ionian zone. The structure of Neogene molasses represents the upper tectonic stage of the structure of the Peri-Adriatic Depression.

In the over part of the section of Kruja zone, the carbonate neritic rocks of the Cretaceous-Paleogene age are overlying the Oligocene flysch of a thickness of 5 km.

The structures of the Albanides are typically Alpine ones. The SSE-NNW directions represent their general strike. The structures are asymmetrical and have a western vengeance. Recumbent, overthrusted and overtwisted structures are found, too. Generally, their western flanks are affected by disjunctive tectonic.

3. METHODS AND STUDY AREA

Geothermal studies carried out in Albania are oriented toward the study of the distribution of the geothermal field and the natural thermal water springs and wells. Geothermal studies were extended all over the country.

The temperatures have been measured and the geothermal gradient and the heat flow density at different depths have also been calculated (Frasheri et al. 1995). Temperature measurements were carried out both in 145 deep wells, in boreholes and in mines, at different hypsometric levels. The temperature in the wells was recorded at regular intervals. It was measured by means of resistance and thermistor thermometers. The average absolute measurement error was 0.3°C. The measurements were carried out in a steady-state regime of the wells filled with mud or water. The recorded data were processed using the trend analysis of first and second degrees. The chemical composition of the waters was found. The output of the springs and wells and their hydrogeology was evaluated.

4. RESULTS

4.1. Geothermal Regime

The Geothermal Regime of the Albanides is conditioned by tectonics of the region, lithology of geological section, local thermal properties of the rocks and geological location (Frasheri A. 1992, Frasheri et al. 1994, 1995, 2004, 2010).

4.1.1. Temperature

The geothermal field is characterized by a relatively low value of temperature. The temperature at 100 meters depth varies from less than 10 to almost 20°C, with lowest values in the mountain regions. The temperature is 105.8°C at 6000 meters depth, in the central part of the Peri-Adriatic Depression. The isotherm runs parallel the Albanides strike (Fig. 1). Going deeper and deeper the zones of highest temperature move from southeast to northwest, towards the center of the Peri-Adriatic Depression and even further towards the northwestern coast. The

temperatures in ophiolitic belt are higher than in sedimentary basin, at the same depth.

4.1.2. Geothermal Gradient

In the External Albanides the geothermal gradient is relatively higher (Fig.2).. The geothermal gradient displays the highest value of about 21.3 $mK.m^{-1}$ in the Pliocene clay section in the centre of Peri-Adriatic Depression. The largest gradients are detected in the anticline molasses structures of the center of Pre-Adriatic Depression (Fig. 5). The gradient decreases about 10-29% where the core of anticlines in Ionic zone contains limestone. The lowest values of 7-11 $mK.m^{-1}$ of the gradient are observed in the deep synclinal belts of Ionic and Kruja tectonic zones.

In the ophiolitic belt of the Mirdita tectonic zone, the geothermal gradient values increase up to 36 $mK.m^{-1}$ at northeastern and southeastern part of the Albania.

4.1.3. Heat Flow Density:

Regional pattern of heat flow density in Albanian territory is presented in the Heat Flow Map. There are observed two particularities of the scattering of the thermal field in Albanides (Fig. 3):

Firstly, maximal value of the heat flow is equal to 42 mW/m^2 in the center of Peri-Adriatic Depression of External Albanides. The 30 mW^{-2} value isotherm is open towards the Adriatic Sea Shelf. These phenomena have taken place owing to the great thickness of sedimentary crust, mainly carbonate one in this zone.

Secondly, in the ophiolitic belt at eastern part of Albania, the heat flow density values are up to 60 mW/m^2. The contours of Heat Flow Density give a clear configuration of ophiolitic belt. Radiogene heat generation of the ophiolites is very low. In these conditions, increasing of the heat flow in the ophiolitic belt, is linked with heat flow transmitting from the depth. The granites of the crystalline basement, with the radiogenic heat generation, represent the heat source.

4.2. Geothermal energy resources in Albania

Large numbers of geothermal energy of low enthalpy resources are located in different areas of Albania. Thermal waters with a temperatures that reach values of up to 65.5°C are sulfate, sulfide, methane, and iodinate-bromide types (Frasheri A. et al. 1996, 2004, 2010) (Tab. 1, Fig.4). In many deep oil and gas wells there are thermal water fountain outputs with a temperature that varies from 32 to 65.5°C (Table 2, Fig. 3)

Albanian geothermal areas have different geologic and thermo-hydrogeological features. Thermal sources are located in three geothermal zones (fig. 4):

Kruja geothermal zone represents a zone with bigness geothermal resources. Kruja zone has a length of 180 km. Kruja Geothermal Zone is extended from Adriatic Sea at North and continues in South-Easter area of Albania and in Konitza area in Greece. Photo 1 shows Lëngarica - Përmet thermal springs at southern Albania. Identified resources in carbonate reservoirs in Albanian side are $5.9x10^8$-$5.1x10^9$ GJ. The most important resources, explored until now, are located in the Northern half of Kruja Geothermal Area, from Llixha-Elbasan in the South to Ishmi, in the North of Tirana. The values of specific reserves vary between 38.5-39.63 GJ/m^2.

Kruja geothermal area represents an anticline structure chain with carbonate core of Cretaceous-Eocene age. They are covered with Eocene- Oligocene flysch. Anticlines are linear with as length of 20-30 km. They are asymmetric and their western flanks are separated from disjunctive tectonics. Geothermal aquifer is represented by a karstified neritic carbonate formation with numerous fissures and micro fissures.

In the Ishmi area, Ishmi 1-b well has been drilled in 1994. It is situated in the top part of the limestone structure. It is located 20 km North- West of Tirana, in the plain area, near "Mother Theresa" Tirana airport. It meets limestone at 1300m of depth and goes through a carbonate coupe of 1016 m thickness.

Kozani 8 well has been drilled in 1989 (Photo 2). It is situated 35 km South- East of Tirana and 8 km North-West of Elbasani. It is situated on hills close to Tirana-Elbasani national road. It meets limestone at 1810m of depth and goes 10m deep in them.

Since the end of the drilling to this day hot water continues to fountain from Ishmi 1-b and Kozani 8 wells.

Elbasani Llixha watering place is about 12 km South of Elbasani. There are seven spring groups that extend like a belt with 320° azimuth. All of them are connected with a the main regional disjunctive tectonics of Kruja zone. Thermal waters flow out through the contact of conglomerate layer with calcolistolith. In this area too, the reservoir is represented by the Llixha limestone structure. These springs have been known before Second World War.

Surface water temperatures in the Tirana-Elbasani zone vary from 60° to 65.5°. In the aquifer top in the well trunk of Kozani 8 temperature is 80°C. Hot water is mineralized, with a general mineralization of 4.6-19.3 g/l. Elbasani Nosi Llixha water has the following formula:

$$H_2S_{0.403}M_{7.1}\frac{Cl_{59}SO^4_{38}}{Na_{46}Ca_{35}}$$

Peshkopia geothermal zone is situated in the Northeast of Albania. Two kilometers East of Peshkopia some thermal springs are situated very close to each other. These thermal springs flow out on

Banja river slope. These springs are linked with the disjunctive tectonic seismic-active zone Ohrid Lake-Debar, at periphery of gypsum diapir of Triassic age that has penetrated Eocene flysch which surround it like a ring. The occurrence of thermal waters is connected with the low circulation zone always under water pressure. They are of sulfate-calcium type, with a mineralization of up to 4.4 g/l, containing 50 mg/l H_2S. Their chemical formula is:

$$H_2S_{0.0495}M_{4.4}\frac{SO_{56}^{4}}{Ca_{65}}$$

Yield of some of the springs goes up to 14 l/sec. Water temperature is 43.5 °C.

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THERMAL WATER SPRINGS IN ALBANIA

Tab 1

N° of Springs	Location	Temperature in °C	Salt in mg/l	Artesian Spring yield in l.s-1
1	Llixha Elbasan	60	6,3	15-18
2	Peshkopi	5-43	4,2	23
3	Lëngarica-Permet	6-31	1,65	>10
4	Sarandoporo-Leskovik	26,7	1,2	>10
5	Tervoll-Gramsh	24	2,5	>10
6	Mamurras-Tirane	21	5,4	>10
7	Steam-Postenani spring			

THE OIL AND GAS WELLS THAT HAVE SELF-DISCHARGE OF THE THERMAL WATER

Tab. 2

N°	Well Name	Temperature in °C	Salt in mg.l-1	Self-discharge in l.sec-1
1	Kozani	65.5	4,6	10,4
2	Ishmi	64	15	4,4
3	Shupal-Tirana	29.5	1,6	1,6
4	Galigati	45-50	5,7	0,9
5	Bubullima	48-50	35	
6	Ardenica 3	38	38,2	15-18
7	Ardenica 12	32	53,6	5-18
8	Semani 1	35		5
	Semani 3	67	20,7	30
9	Verbasi	29.3	8,2	1-3

Water temperature and large yield, stability, and also aquifer temperature of Peshkopia Geothermal Area similar are with those of Kruja Geothermal Area. For this reason geothermal resources of Peshkopia Area have been estimated to be similar to those of Tirana-Elbasani area.

Ardenica geothermal zone is located in the coastal area of Albania, in sandstone reservoirs.

Photo 1. Langarica-Permeti thermal water springs

Photo 2. Geothermal deep well Kozani - 8

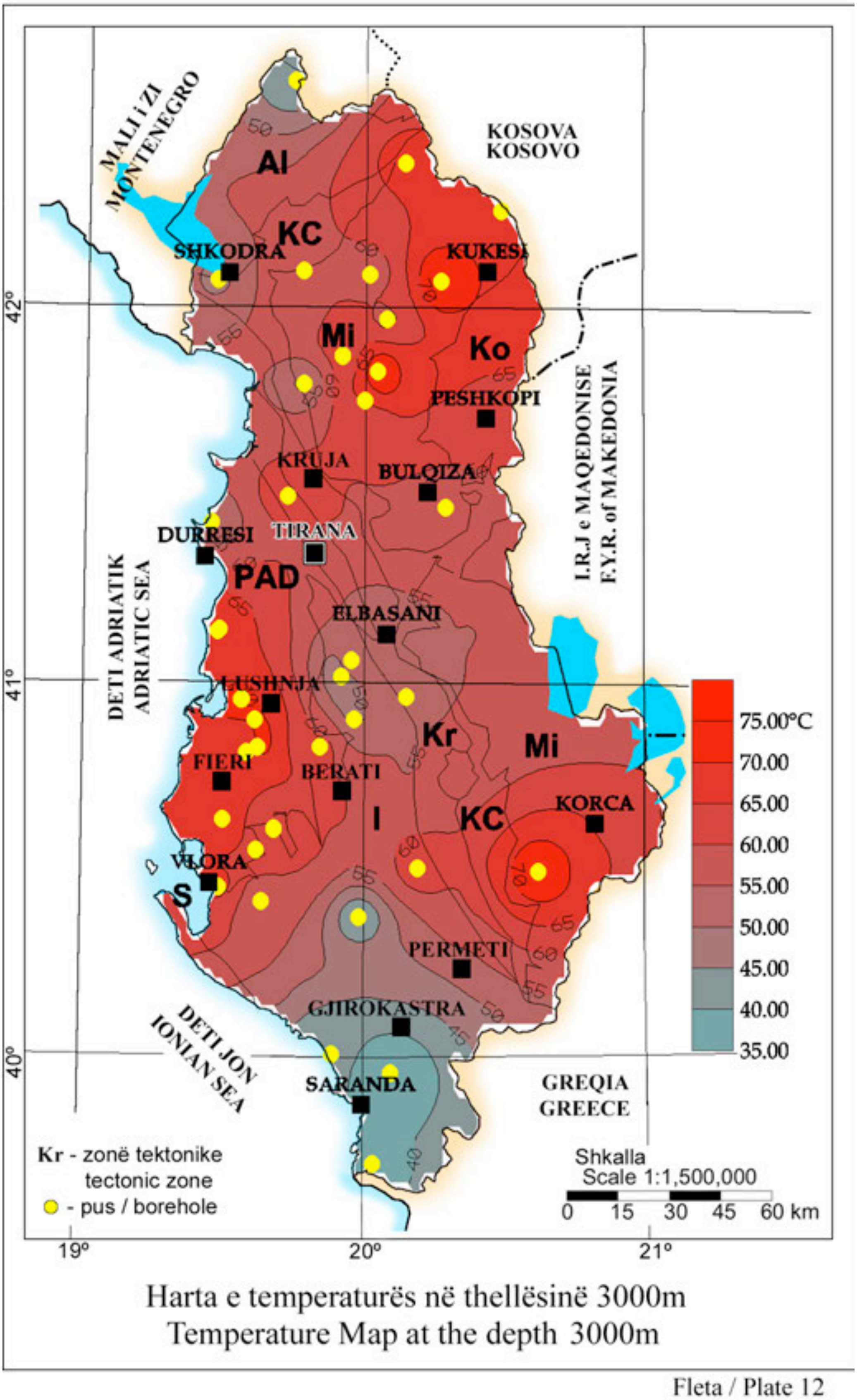
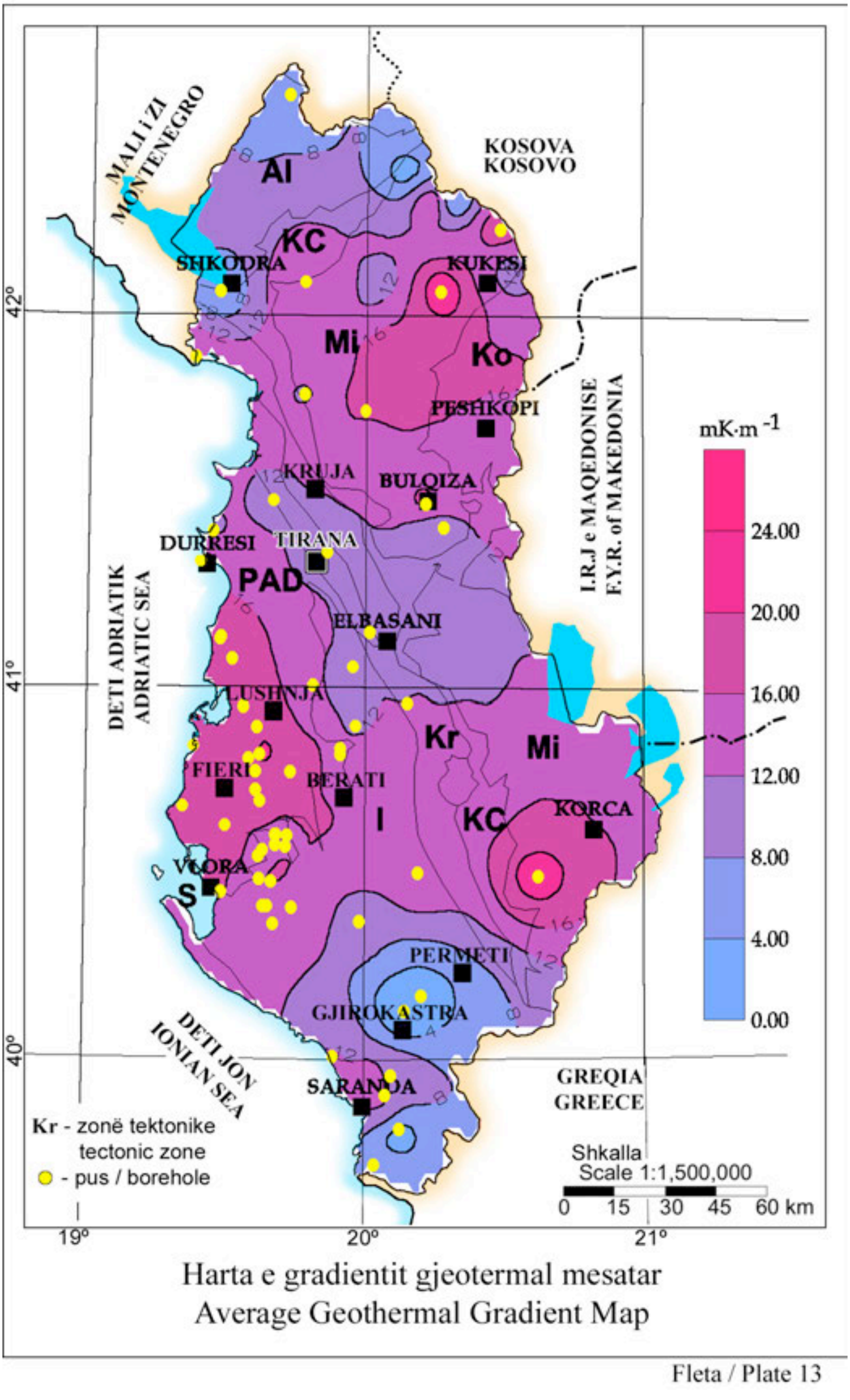

MALI i ZI
MONTENEGRO
KOSOVA
KOSOVO
Al
KC
SHKODRA
KUKESI
Mi
Ko
PESHKOPI
KRUJA
BULQIZA
DURRESI
TIRANA
PAD
ELBASANI
LUSHNJA
Kr
Mi
FIERI
BERATI
I
KC
KORCA
VLORA
S
PERMETI
GJIROKASTRA
SARANDA
GREQIA
GREECE
DETI ADRIATIK
ADRIATIC SEA
DETI JON
IONIAN SEA
I.R.J e MAQEDONISE
F.Y.R. of MAKEDONIA
75.00°C
70.00
65.00
60.00
55.00
50.00
45.00
40.00
35.00
Kr - zonë tektonike
tectonic zone
- pus / borehole
Shkalla
Scale 1:1,500,000
0 15 30 45 60 km
19°
20°
21°
42°
41°
40°
Harta e temperaturës në thellësinë 3000m
Temperature Map at the depth 3000m
Fleta / Plate 12

Fig. 1


MALI i ZI
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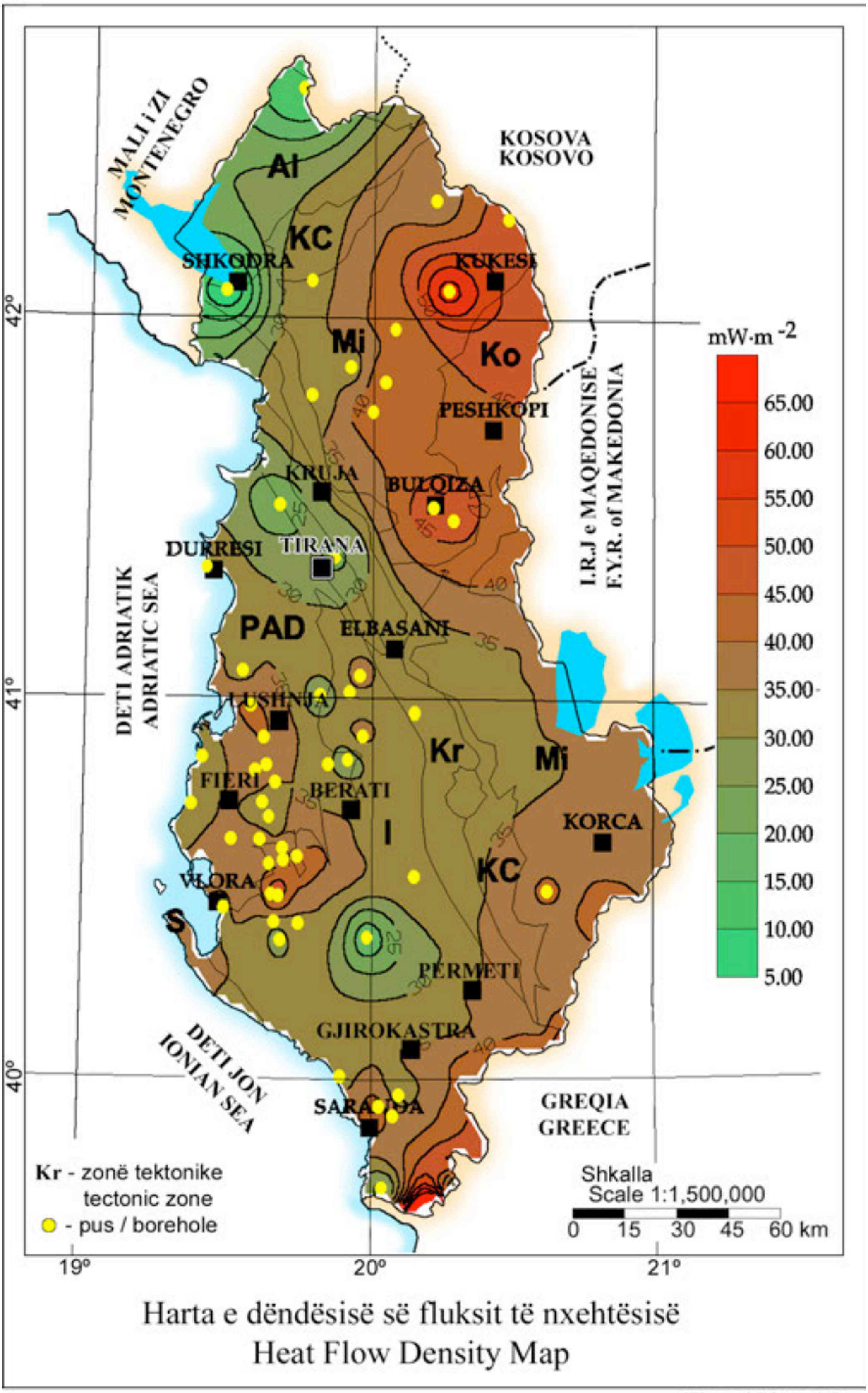
GREQIA
GREECE
mK·m -1
24.00
20.00
16.00
12.00
8.00
4.00
0.00
42°
41°
40°
19°
20°
21°
Kr - zonë tektonike
tectonic zone
- pus / borehole
Shkalla
Scale 1:1,500,000
0 15 30 45 60 km
Harta e gradientit gjeotermal mesatar
Average Geothermal Gradient Map
Fleta / Plate 13

Fig. 2



Harta e dëndësisë së fluksit të nxehtësisë
Heat Flow Density Map

Fleta / Plate 16

Fig. 3

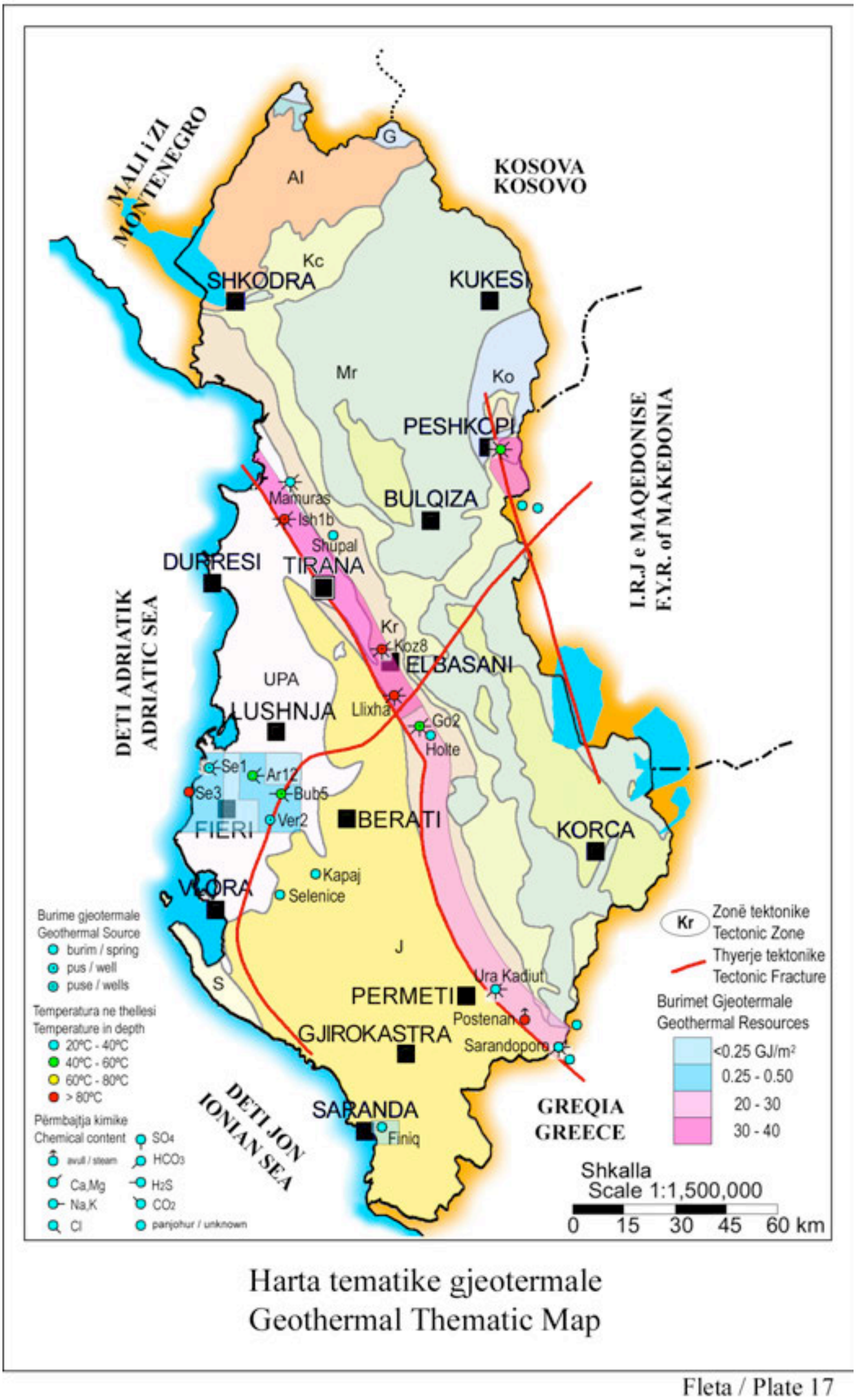

MALI i ZI
MONTENEGRO
KOSOVA
KOSOVO
I.R.J e MAQEDONISE
F.Y.R. of MAKEDONIA
DETI ADRIATIK
ADRIATIC SEA
DETI JON
IONIAN SEA
GREQIA
GREECE
SHKODRA
KUKESI
PESHKOPI
BULQIZA
DURRESI
TIRANA
ELBASANI
LUSHNJA
FIERI
BERATI
KORCA
VLORA
PERMETI
GJIROKASTRA
SARANDA
Al
G
Kc
Mr
Ko
Kr
UPA
J
S
Mamuras
Ish1b
Shupal
Koz8
Llixha
Gd2
Holte
Se1
Ar12
Se3
Bub5
Ver2
Kapaj
Selenice
Ura Kadiut
Postenani
Sarandoporo
Finiq
Burime gjeotermale
Geothermal Source
burim / spring
pus / well
puse / wells
Temperatura ne thellesi
Temperature in depth
20ºC - 40ºC
40ºC - 60ºC
60ºC - 80ºC
> 80ºC
Përmbajtja kimike
Chemical content
SO4
HCO3
Ca,Mg
H2S
Na,K
CO2
Cl
panjohur / unknown
Zonë tektonike
Tectonic Zone
Thyerje tektonike
Tectonic Fracture
Burimet Gjeotermale
Geothermal Resources
<0.25 GJ/m2
0.25 - 0.50
20 - 30
30 - 40
Shkalla
Scale 1:1,500,000
0 15 30 45 60 km
Harta tematike gjeotermale
Geothermal Thematic Map
Fleta / Plate 17

Fig. 4

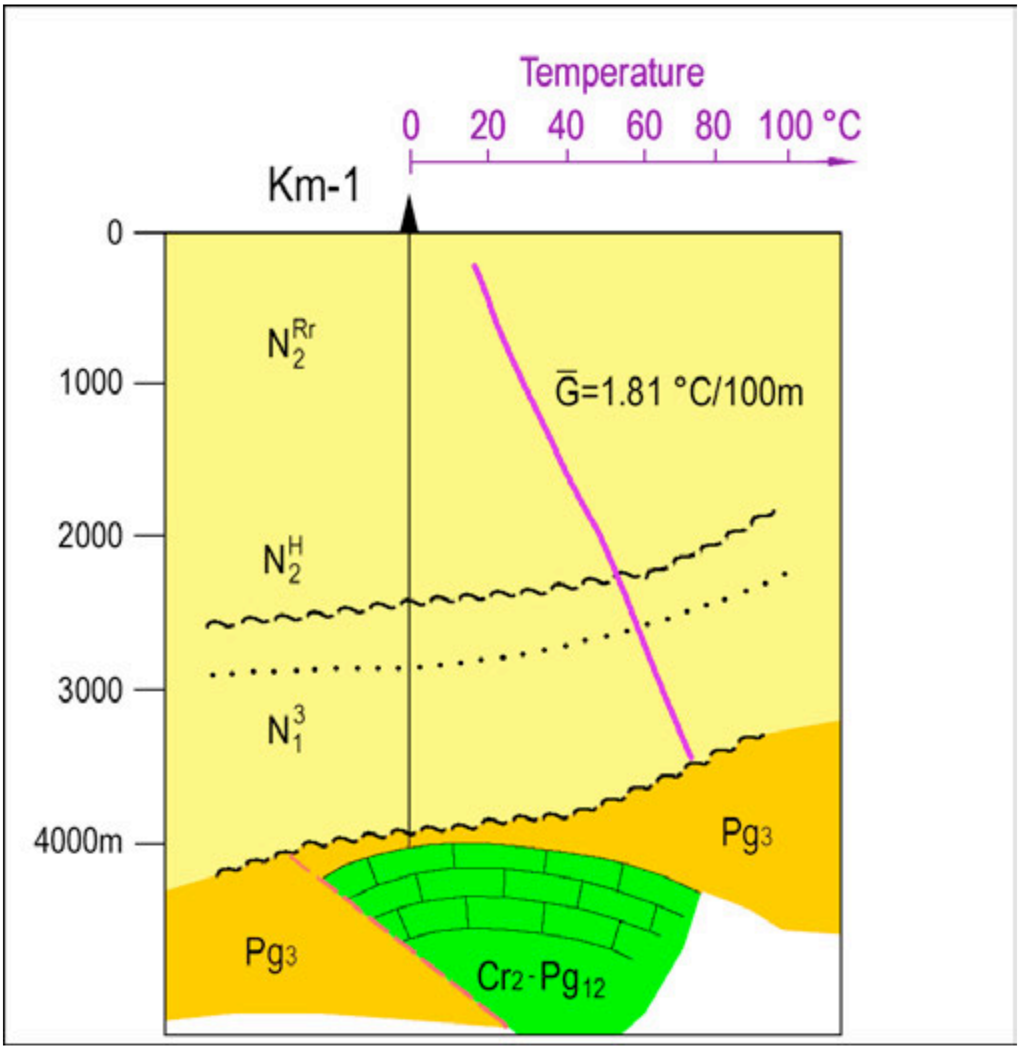


Fig. 5 - Geothermal Section Peri-Adriatic Depression

5. PLATFORM FOR THE DIRECT USE OF GEOTHERMAL ENERGY OF LOW ENTHALPY IN ALBANIA

The geothermal situation of low enthalpy in Albania offers three possibilities for the direct use of geothermal waters energy. Geothermal energy exploitation must be realized by integrated scheme of geothermal energy, heat pumps and solar energy, and cascade use of this energy (Frashëri A. 2001, Frasheri A. et al. 2003, 2004, 2008,2009, 2010).

Firstly, the Ground Heat can be use for space heating and cooling by Borehole Heat Exchanger-Geothermal Heat Pumps modern systems. At the present in Albania have been installed geothermal heating systems in six buildings in different cities: Tirana, Korça, Shkodra, Erseka.

Secondly, thermal sources of low enthalpy and of maximal temperature up to 65.5°C.

Thermal waters of springs and wells may be used in several ways:

1. Modern Wellness SPA for treatment and healing of different diseases, recreation, thermal physical and mental relaxation, with thermal bath and pools, sauna, massages, fitness and activities for development of eco-tourism. Such centers may attract a lot of clients not only from Albania, because the good curative properties of waters and springs are situated at nice places, near seaside, Gjinari Mountain or Ohrid Lake.

The oldest and important is Elbasani Llixha SPA is located in Central Albania. By national road communication, Llixha area is connected with Elbasani. These thermal springs from about 2000 years ago are known, near of the old road “Via Egnatia" that has passed from Durresi-Ohrid- to Constantinople. All seven groups of the springs in Llixha Elbasani and Kozani-8 well, near of Saint Vladimir Monastery at Elbasani, have the possibilities for modern complex exploitation. Ishmi 1/b geothermal well is located in beautiful Tirana field, near of Mother Theresa- Tirana Airport, near of the Adriatic coastline and Kruja - Skanderbeg Mountain.

Peshkopia SPA was constructed by modern concepts as balneological geothermal center. There are thermal pools, for medical treatment and recreation. Construction of the Peshkopia SPA must been good example for new SPA construction in Albania.

2. The hot water can be used also for heating of hotels, SPA and tourist centers, as well as for the preparation of sanitary hot water used there.

3. Near thermal water springs and wells it is possible to build the greenhouses for flowers and vegetables, asparagus cultivation, etc.

4. Aquaculture installations for cultivation of the micro-alga as spirulina etc. for alimentary industry, preparation of pomades, and fish cultivation will be other profitable activities.

5. From thermal mineral waters it is possible to extract very useful chemical microelements as iodine, bromine, chlorine etc. and other natural salts, so necessary for preparation of pomades for the treatment of many skin diseases as well as for beauty treatments. From these waters it is possible to extract sulphidric and carbonic gas.

6. Scientific research for study of the possibility of generating electricity from geothermal sources of low enthalpy, about 80^{o}C, as good local energy sources and provides a secure domestic energy supply with stable output.

Thirdly, the use of deep doublet abandoned oil and gas wells and single wells for geothermal energy, in the form of a "Vertical Earth Heat Probe". The geothermal gradient of the Albanian Sedimentary Basin has average values of about 18.7 $mK \cdot m^{-1}$. At 2 000 m depth the temperature reaches a value of about 48°C. In these single abandoned wells a closed circuit water system can be installed. Near of these wells, can be build greenhouses.

Actually in Albania is prepared a platform with scenarios for integrated and cascade use of the geothermal energy, in the framework of the National Program for Research and Development, Water and Energy (2007-2009). Based on complex analysis, for the best area selected according to the scenarios, a Feasibility Study is performed to analyze three components: energy supply, environmental impact and financial aspects, and to suggest the best solution of the innovative geothermal energy utilization technology applications in that area.

Consequently, the sources of low enthalpy geothermal energy in Albania, which are at the same time the sources of multi-element mineral waters, they represent the basis for a successful use of modern technologies for a *complex and cascade exploitation* of this environmental friendly renewable energy, achieving a economical effectiveness. Such developments are useful also for the creation of new working places and improvement of the level of life for local communities near thermal sources.

6. CONCLUSIONS

1. Albania has geothermal energy resources, which can be direct use as alternative, environmental friendly energy.

2. Resources of the geothermal energy in Albania are;

- Natural springs and deep wells with thermal water, of a temperature up to 65.5°C.
- Heat of subsurface ground, with an average temperature of 16.4^{o}C and depth Earth Heat Flow.

3. Construction of the space-heating system, based on direct use of ground heat, by using of the shallow borehole heat exchanger (BHE)-Heat Pumps systems, is actually most important direction of the use of geothermal energy.

7. ACKNOWLEDGMENTS

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between the Republic of Italy
and the Republic of Albania
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KONTRIBUTE PER PERMIRESIMIN E FUSHAVE TE ZBATIMEVE EUROPIANE TE GJEOFIZIKES NE SHQIPERI, NE KONTEKSTIN E PROTOKOLLIT TE BOLONJES

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Treguesi i lëndës

Pjesa e parë

ZHVILLIMI DHE NIVELI SHKENCORO-TEKNOLOGJIK I GJEOFIZIKES NE SHQIPERI

Studimet dhe kërkimet gjeofizike janë kryer në Shqipëri për më shumë se 60 vjet, kryesisht për kërkimin e naftës e të gazit, të mineraleve xeherore dhe për studimet krahinore. Fillimet e para të kërkimeve gjeofizike i përkasin viteve tridhjetë, me rilevimet gravimetrike, magnetometrike dhe sondime elektrike të kryera nga shoqëri italiane në vitet 30-40 në Kuçovë, në Selenicë, në Derven etj. Kërkimet gjeofizike në poligonë të mëdhenj dhe sistematike filluan ne vitet 50-të, për kërkimin e naftës dhe të gazit. Gradualisht, metoda të ndryshme filluan të zbatohen:

- Rilevimet gravimetrike për kërkimin e naftës, nga viti 1950.
- Sondimet elektrike në Ultësirën Pranadriatike në kuadrin e kërkimeve të naftës dhe të gazit, që nga viti 1950,
- Karotazhet e puseve të naftës, që nga viti 1950.
- Punimet sizmike të para filluan të kryhen në vitin 1952 per kërkimin e naftës dhe të gazit,
- Punimet elektrometrike për kërkimin e bakrit nga viti 1953, si edhe të kromit me rilevimet magnetometrike në vitin (1957) dhe gravimetrike (1958).
- Studimet radiometrike nga viti 1959.
- Temperaturat në thellësi të tokës në puset e thellë të naftës janë regjistruar qysh nga viti 1951, por studimet gjeotermike të specializuara filluan në vitin 1989.
- Studimi dhe kërkimet gjeofizikë në shelfin detar të Adriatikut, me vrojtime eksperimentale prej vitit 1973 dhe në përiudhën 1982-1984 për kërkim në të gjithë shelfin nga Vlora në Shëngjin.

Punimet gjeofizike në vitet tridhjetë u kryen nga gjeofizikët e shoqërive italiane. Kërkimet gjeofizike në fillimin e viteve pesëdhjetë u kryen nga gjeofizikë sovjetike dhe gjermanë. Nga viti 1951 u kthyen nga studimet jashtrë shtetit inxhinjerët e parë gjeofizikë Teki Biçoku e Hasan Topçiu (1951), Ligor Lubonja (1957) dhe Nevruz Kodheli (1960). Në atë kohë u përgatitën edhe teknikët e parë gjeofizikë, në karotazhet e naftës Hamdi Bejtja (1951), Alfred Frashëri (1953), Vasil Nasi (1956), Pertef Nishani (1957) etj., për punimet sizmike Besnik Pustina (1954), etj. U rispecializuan si gjeofizikanë inxhinjerë të specialiteteve të tjera, i pari midis të cilëve Agim Luari (1955), Anastas Dodona (1959), etj.

Studimet gjeofizike në Shqipëri nga viti në vit erdhën duke u zhvilluar si kompleks metodash, si nivel teknologjik vrojtimi dhe interpretimi , si edhe është ngritur më lart bashkërendimi me metodat e tjera gjeologjike e gjeokimike. Një analizë e hollësishme e zhvillimit

dhe nivelit të tyre do të bëhet në paragrafët e mëposhtëm, veçmas për sejcilën metodë.

Deri në vitet nëntëdhjetë, studimet dhe kërkimet gjeofizike kryheshin nga:

1. *Ndërmarrja Gjeofizike*, e cila më pas u shndërrua në *Qëndrën e Kërkimeve Gjeofizike dhe Gjeokimike*, në shërbimin Gjeologjik Shqiptar, me qendër në Tiranë,
2. *Ndërmarrja Albseis* e industrisë së naftës, me qendër në Fier,
3. *Ndëmarrja e Gjeofizikës Kantierale* në Industrinë e Naftës, në Patos.
4. *Institutin e Naftës e të Gazit,* në Fier.

Në Ndërmarjen Gjeologji-Gjeodezi të Ministrisë së Ndërtimit dhe në atë të Hidrogjeologjisë kanë funksionuar dy ekspedita gjeofizike të specializuara për gjeofizikën inxhinjerike (1983) dhe kërkimet e ujit në fillimin e viteve tetëdhjetë.

Studimet Sizmologjike të tërmeteve dhe të sizmologjisë inxhinjerike kryhen nga *Instituti i Sizmologjisë* së Akademisë së Shkencave.

Përgatija e inxhinjerëve gjeofizike dhe kualifikimi i tyre pasuniversitar bëhet në *Seksionin e Gjeofizikës* në Fakultetin e Gjeologjisë dhe të Minierave, Universiteti Politeknik i Tiranës, qysh prej vitit 1961.

Gjeofizikanët Shqiptarë kanë krijuar qysh në vitin 1989 edhe *Shoqatën Gjeofizike të Shqipërisë*, e cila është pjesë e Bashkimit Shqiptar të Gjeoshkencëtarëve dhe Inxhinjerëve, si edhe anëtare e European Association of Geoscientists and Engineers dhe e Balkan Geophysical Society.

Kërkimet gjeofizike ne Shqipëri kanë një spektër të gjerë të zbatimit të tyre:

1. Në ndihmë të rajonizmit tekntonik të Albanideve dhe të hartografimeve gjeologjike të shkallëve të ndryshme,
2. Të kërkimit dhe gjatë shfrytëzimit të vendburimeve të naftës e gazit,
3. Në kërkimin dhe zbulimin e mineraleve metalore si bakri, kromi, hekur-nikeli, boksidet, minerale të tjera si azbesti, sera, qymyret e gurit, fosforitet, shkrifërimet e mineraleve të rënda, të rralla e të çmuara, kripërat, të materialeve të ndërtimit,
4. Në studimin e truallit ku janë ndërtuar hidrocentrale, hekurudha, fabrika e uzina, banesa qytetare, tunele, në vlerësimin e stabilizimit të shpateve, në vlerësimin e gjendjes së digave të hidrocentraleve dhe të sistemeve të ujitjes, të ndërtesave etj.
5. Për zgjedhjen e detyrave mjedisore për njohjen e gjeomjedisit dhe impakteve mbi të.

Punimet gjeofizike janë shtrirë në stere dhe në shelfin e Detit Adriatik.

Drejtim i rëndësishëm i gjeofizikës në Shqipëri janë studimet sizmologjike. Ato janë kryer nga Instituti i Sizmologjisë, Akademia e Shkencave. Këto studime i përkasin tre fushave: sizmotektonike, sizmologjia inxhinjerike dhe inxhinjeria e tërmeteve. Stacioni i parë sizmologjik u ngrit në vitin 1968 pranë Katedrës së Gjeofizikës (E. Sulstarova, S. Koçiu) dhe në 1972 u ngrit Qendra Sizmologjike në Akademinë e Shkencave, e cila ndërtoi rrjetin sizmologjik të Shqipërisë me 13 stacione: Tiranë, Korçë, Shkodër, Kukës, Vlorë, Sarandë etj.

Për kryerjen e kërkimeve dhe punimeve gjeofizike kanë punuar 276 inxhinjerë gjeofizikë, si edhe dhjetra fizikanë, inxhinjerë elektrikë e radioteknikë etj. Midis tyre ka 45 doktorë shkencash, 7 profesorë, 1 asistent professor, 9 drejtues kërkimi dhe 12 mjeshtra kërkimesh. Ndër studiuesit në fushën e gjeofizikës së zbatuar kanë dhënë kontributin e çmuar Prof. Dr. Alfred Frashëri, Drejtues Projekti, Dr. Ali Mema, Dr. Aleko Stamata, Inxh. Agim Luari, Inxh. Anastas Dodona, Mjeshtër Kërkimi Dr. Caush Xhufi, Prof. Dr. Daver Çano, Inxh. Enriko Veizi, Inxh. Hasan Topçiu, Inxh. Hidai Haxhiu, Mjeshtër Kërkimi Dr. Fatmir Fezga, Mjeshtër Kërkimi Dr. Ferdinat Dafa, Dr. Kliti Verria, Drejtues Kërkimi, Dr. Llambi Langora, Doc. Ligor Lubonja, Inxh. Neim Çavani, Inxh. Nevruz Kodheli, Fizikant Nikolin Leka, Prof. Dr. Pertef Nishani, Prof. Dr. Përparim Alikaj, Drejtues Kërkimi. Dr. Radium Avxhiu, Prof. Dr. Rushan Liço, Dr. Salo Arapi, Prof. Dr. Salvator Bushati, Prof. Dr. Siasi Koçiu, Dr. Stavro Dhima, Prof. Dr. Akademik Teki Biçoku, Dr. Thanas Andoni, Drejtues Kërkimi Dr. Vilson Bare, Dr. Vladimir Veizaj, etj.

Në fushën e sizmologjisë renditen për kontributin e tyre: Prof. Dr. Akademik Eduard Sulstarova, Prof. Dr. Siasi Koçiu, Prof. Dr. Shyqyri Aliaj, Prof. Dr. Betim Muço, Prof. As. Dr. Jani Skrame, Prof. As. Dr. Llambro Duni etj.

Në Shqipëri studimet dhe kërkimet komplekse gjeofizike janë realizuar me anën e metodave: gravimetri, magnetometri, elektrometri, sizmikë, radiometri, gjeotermi dhe studimi gjeofizik i puseve (karotazh). Ka qënë e rëndësishme ndihmesa e gjeofizikës në zbulimin e vendburimeve të naftës Marinzë, Kallm-Vërri, Kolonjë, Vurg, Cakran, Mollaj, Amonicë etj, si edhe të gazit Divjakë, Veri të Divjakes, Ballaj-Kryevidh, Frakull, Povelçë, Panaja , Durres, të bakrit në Gjegjan, Tuç, Qafe Bari, Kaçinar, Palucë e Laku i Roshit, Karmë, Perlat, Golaj etj, si edhe gjatë kërkim-zbulimit të vendburimeve të kromit, të fosforiteve, të qymyreve, të boksideve, të asbestit etj. Hartat krahinore gravimetrike, magnetike, gjeotermale dhe të rajonizimit sizmologjik janë pjesë e rëndësishme e studimeve për njohjen e ndërtimit gjeologjik të Albanideve.

Gjatë një periudhe pesëmbëdhjetë vjeçare, vitet e fundit, rezultatet më të mira të kërkimeve dhe studimeve gjeofizike janë botuar në periodikun shkencor dhe si monografi, si edhe janë referuar me sukses në konferenca e kongrese shkencore në vend dhe ndërkombetare, në Europë, SH.B.A., në Japoni etj.

Pesëmbëdhjetë vitet e fundit përfaqësojnë edhe periudhen e zgjerimit të fushave të zbatimit të metodave gjeofizike për zgjidhjen e detyrave gjeoteknike (studimi i truallit në zonat e ndërtimit, kontrolli i digave dhe i qëndrueshmërisë së shpateve dhe të rrëshqitjeve), kërkimet hidrogjeologjike, mikrozonimi i qyteteve kryesore të Shqipërise, studimi dhe vlerësimi i energjisë gjeotermale, studime të gjeomjedisit dhe të impakteve mbi të, etj.

Përgatitja e inxhinjereve gjeofizike dhe kualifikimi i tyre pasuniversitar është kryer vazhdimisht në Degen e Gjeofizikës në Departamentin e Shkencave të Tokës, Fakulteti i Gjeologjisë dhe i Minierave, pranë Universiteti Politeknik i Tiranës. Periudha e studimeve është 5 vjet për inxhinjeret, 1 vit për SHPU dhe 3 vjet për studimet e doktoratës. Sipas planit mësimor të hartuar në kuadrin e Protokollit të Bolonjës dhe që ka filluar të zbatohet në vitin akademik 2005-2006, periudha e studimeve do të jetë 3 vjet për *diplomën bachelor* dhe 2 vjet për *diplomën master*. Aktualisht, Seksioni i gjeofizikës po punon për ti hartuar edhe programet e lëndëve mësimore në pajtim me zhvillimet aktuale të gjeofizikës, kërkesat e ekonomisë së tregut dhe sipas planit mësimor të përpiluar në kuadrin e zbatimit të Protokollit të Bolonjës.

1. ZHVILLIMI I PUNIMEVE SIZMIKE NE SHQIPERI

Punimet sizmike ne Shqiperi filluan te kryhen per here te pare ne vitin 1952, ku ne kuadrin e Ndermarrjes se Nafte-Gaz-Bitumit, qe merresh me studime gjeologjike strukturore dhe me kerkimin e naftes, gazit e bitumit, u krijua edhe ekspedita sizmike me dy stacione sizmike me regjistrim oshilografik 26 kanalesh te tipit SS-26D, prodhim sovjetik. Ekspedita drejtohej nga specialistet sovjetike.

U eksperimentua zbatimi i sizmikes me vale te reflektuara, ne rajone me relief pergjithesisht te qete dhe me dalje strukturash ne siperfaqe, si ne Frakull, Ardenice etj. Nga punimet e para eksperimentale, megjithese me metodike fare te thjeshte, me nga nje sizmomarres per kanal, u pa se metoda eshte efektive dhe merrej material i interpretueshem dhe ne thellesi te pranueshme, 2000-2500 metra. Bazuar ne keto rezultate, punimet sizmike filluan te zgjerohen, duke forcuar edhe bazen materialo-teknike, aparaturat regjistruese, sondat e shpimit etj. Keshtu ne vitin 1956 erdhen aparatura te reja regjistruese, 60 kanaleshe te tipi SS 30/60 prodhim sovjetik.

Ne vitet 1957-1958 u eksperimentua edhe metoda e valeve te thyera per zgjidhjen e problemeve te vecanta si ndjekja dhe studimi i

tavanit te gelqeroreve ne strukturen e Fushe Krujes, ku nga rezultatet e marra rezultoi se metoda e valeve te thyera (MVTH) mund te perdoret per zgjidhjen e problemeve te vecanta e specifike, por si metode kryesore sizmike per studime mbetet metoda e valeve te reflektuara (MVR). Raportet gjeologjike per rezultatet e punimeve sizmike,si edhe per punimet e tjera, ne ate kohe mbroheshin dhe miratoheshin ne bashkimin sovjetik.

Gjate kesaj kohe erdhen edhe kuadrot e para gjeofizike qe ishin pergatitur jashte shtetit, si Inxhinier Teki Biçoku e Hasan Topçiu (1952), dhe me pas Novruz Kodheli (1960), Siasi Koçiu (1961) dhe u formuan edhe specialiste per kryerjen e punimeve si sondiste, minatore etj. Ne vitet 1959-1960 tashme ekspedita sizmike kishte 4 stacione sizmike, nder te cilet tre stacione 60 kanaleshe dhe nje stacion 24 kanalesh.

Me largimin e specialisteve sovjetike ne vitin 1961, kryerja e punimeve sizmike u muar ne dore nga specialistet shqipetare dhe u cua me perpara. Krahas specialisteve gjeofizike te pergatitur jashte shtetit, ne kryerjen e punimeve u angazhuan edhe speciliste te tjere si matematiciene, fizikane, gjeologe, si Nikolin Leka e Engjell Saliu (1960) dhe Enriko Veizi e Alfred Frasheri (1961), etj. Po ne vitin 1961 ne kuadrin e ristrukturimit te punimeve gjeologjike, ekspedita sizmike u bashkua me “Bazen e Karotazhit” (Gjeofizika Kantjerale) qe vepronte brenda sistemit te naftes duke formuar Ndermarrjen Gjeofizike brenda sistemit te naftes. Punohej thuajse teresisht me metoden e valeve te reflektuara.

Me qenese regjistrimi ishte oshilografik (fotografik) me diapazon regjistrimi jo me shume se 40 decibelle dhe perpunimi behej teresisht me dore, per sigurimin e cilesise sa me te mire te te dhenave sizmike, rendesi shume e madhe i kushtohej zgjedhjes se parametrave fushore te ngacmimit dhe pranimit te valeve, duke kryer nje volum te konsiderueshem punimesh eksperimentale per zgjedhjen e parametrave te punes sipas kushteve konkrete siperfaqesore dhe te thellesise te rajoneve te dhena, gje qe kerkonte thellim e studim nga ana e specialisteve te sizmikes.

Me kete teknike e metodike pune u vazhdua deri ne fillimin e viteve ‘70 kur u futen ne perdorim stacionet me regjistrim magnetik analoge, duke mbuluar me punime sizmike nje pjese te mire te rajoneve qe gjykoheshin perspektive per kerkimin e naftes e gazit dhe qe ishin te arritshem krahas teknikave dhe teknologjive të kohes.

Ne vitin 1965 u eksperimentua serish ne Dumre Metoda e Valeve te Thyera, me qellim ndjekjen dhe studimin e tavanit te kriprave ne diapirin e Dumrese, e cila rezultoi e suksesehme dhe dha ndihmesen e saj ne zgjidhjen e disa problemeve gjeologjike te kohes per kete strukture.

Nevojat per permiresimin e cilesise dhe rritjen e thellesise se studimit me sizmike, bene qe ne tematiken e studimeve eksperimentale te shtrohen probleme te tilla si rritja e ndieshmerise se kanaleve sizmike, lufta kunder valeve te demeshme, rritja e energjise se valeve te reflektuara nga thellesia etj. per te cilat u kryen studime teorike dhe zbatime praktike ne perdorimin e sistemeve regjistruese interferenciale (grupimet e sizmografeve dhe plasjeve, zgjedhja e largesise midis kanaleve etj), duke kryer per kete qellim nje sere studimesh me vlere.

Sipas kerkesave te kohes u kalua edhe ne rajone me terren te veshtire, kodrinoro – malor, dhe me ndertim gjeologjik me et nderlikuar, te cilat shtruan probleme te reja per zgjidhje, si ne drejtimin organizativ te punimeve ashtu dhe ne drejtimin teknik te tyre, si ne drejtim te domosdoshmerise se llogaritjes dhe futjes se korigjimeve per relief ,per zonen e shpejtesive te vogla si edhe probleme te paisjes se ekspeditave me mjete terheqese traktore e buldozere, shtimin e numrit te sondave te shpimit etj.

Gjate viteve 1963 dhe 1964 u pergatiten ne Universitetin Shteteror te Tiranes 21 kuadrot e para gjeofizike, 7 prej te cileve u emeruan dhe punuan ne sizmike, si Ali Mema, Petrit Sadushi, Petref Nishani, Mihallaq Malaveci, Tomor Meço, Ahmet Çollaku, etj.

Ne vitin 1969, me ardhjen e dy ekspeditave sizmike kineze te paisura me stacione me regjistrim magnetik analog 25 kanalesh, te tipit DZ-663 dhe me paisjet perpunuese analoge te prodhimit kinez, filloi etapa e regjistrimit magnetik analog, ku materialet tashme ishin te riprodhueshme dhe mund te perpunoheshin me tej ne paisjet laboratorike gjithashtu analoge. Kjo krijoi mundesi te reja ne drejtim te rritjes se cilesise se materialeve sizmike dhe sidomos te interpretimit te materialeve. U bene perpjekjet e para per eksperimentimin e metodes se mbulimit shumefish, qe kishte filluar te perdorej ne bote, por shtroi edhe kerkesa me te medha ne drejtim te pergatitjes se materialit per perpunim, sidomos ne drejtim te korigjimeve statike e dinamike, studimin e shpejtesive etj. prandaj dhe ne kete kohe filloi studimi sistematik i pjeses se siperme te prerjes gjeologjike, pra studimi i zones se shpejtesive te vogla (ZSHV) me metoden e valeve te thyera, qe sherbeu per llogaritjen dhe futjen me te sakte te korigjimeve gjate perpunimit. Tashme interpretimi i materialeve behej mbi prerjet e kohes dhe jo mbi sizmogramat e regjistruara ne fushe. U krijuan mundesite e migrimit te prerjeve, mundesi me te medha per analizat dhe njohjen e shpejtesive te perhapjes se valeve etj.

Nderkohe ishin bere edhe disa ndryshime administrative, sizmika ne vitin 1969 u be pjese e Institutit te Naftes i cili u transferua nga Kucova ne Fier. Ne sizmike kishin ardhur disa kuadro te reja sidomos nga degat e matematikes dhe fizikes industriale, te cilet u angazhuan seriozisht dhe u ingranuan shpejt e mire ne kryerjen dhe drejtimin e

punimeve sizmike. Po keshtu qe nga viti 1973 filluan te vijne edhe inxhinieret gjeofizike te pergatitur ne Fakultetin e Gjeologjise dhe te Minierave te Universitetit te Tiranes, e cila u hap ne vitin 1968, te cilet dhane nje kontribut te çmuar ne zhvillimin e sizmikes. Midis te cileve permendim Inxh. Arqile Berberi, Vilson Sillo, Halim Dariu, Spiro Haskaj, Simon Davidi, Xhemil Buzi, Caush Xhufi, Luan Kellici, Durim Goxhaj, Lefter Jani, Spiro Kolonjari, Kristaq Jano, Frederik Qyrana, Spartak Nasto, Spiro Bonjaku, Faslli Fejzullahu, Ethem Seitaj, Mira Kallajxhi, Jani Skrami, Sofie Zogaj, etj.

Ne fillimin e viteve '70 filloi edhe nje fare hapje ne drejtim te perendimit me te perparuar, keshtu filloi te zbatohej nje fare levizje e specialisteve gjeofizike ne perendim per te pare tekniken e teknologjine dhe per marrje pervoje ne kete drejtim, apo edhe dergime specialistesh per specializime e kualifikime. Ne baze te literatures dhe te pervojes se marre u shtruan kerkesat per regjistrimin shifror te materialeve sizmike, fillimisht sidomos per perpunimin shifror te tyre. Ne vitin 1972 u arrit marreveshja per blerjen e qendres elektronike te perpunimit te materialeve sizmike. U derguan ne Gjermanine Perendimore 6 specialiste per pervetesimin e venien ne pune te paisjeve dhe me filimin e vitit 1973 u vu ne perdorim qendra e perpunimit elektronik me kompjuter Raytheon-707, e cila perpunonte materialet e regjistruara me stacionet magnetike analoge tashme ne perdorim, duke siguruar me pare transformimin e materialit nga analog ne shifror nepermjet paisjeve speciale periferike. Po keshtu kishte edhe nje paisje tjeter qe siguronte shifrimin (digitalizimin) e regjistrimeve oshilografike por me perdorim te kufizuar. Kjo solli qe edhe ne metodiken fushore te behen permiresime e ndryshime te rendesishme, u fut ne shkalle te gjere metodika e mbulimit shumefish, megjithese me shkalle te ulet fishmerie per shkak te numrit te vogel te kanaleve ne stacionet regjistruese.

Te gjitha keto dhe sidomos disa arritje ne zbulimin e shtratimeve e vendburimeve te reja te naftes e gazit, si ne Kallm-Verri, Kolonje, Vurg, Cakran , Amonice, ku përdorimi i sizmikës nga specialistet sizmike si Enriko Veizi, Petref Nishani, Petrit Sadushi, Ali Mema, Novruz Kodheli, fizikantet Drini Mezini, Vilson Bare, Vullnet Xhango, Andrea Toska, Aleko Stamati etj. kishin kontributin e tyre, bene qe edhe detyrat te shtoheshin dhe te rriteshin me tej kerkesat per shtimin e kompleksit te metodave gjeofizike ne kerkimet e naftes dhe te rriteshin kerkesat ndaj sizmikes si ne drejtim te cilesise ashtu dhe te rritjes se metejshme te thellesise se studimit. Prandaj ne mesin e viteve '70 ne bashkepunim me Katedren e Gjeofizikes, pranë Fakultetit të Gjeologjisë dhe të Minierave, u shtua kontributi i metodes gravimetrike (Ligor Lubinja) dhe u futen disa metodika te elektrometrise ne kerkimet e naftes (Alfred Frashëri), filluan perpjekjet e para per mundesine e perdorimit te te dhenave gjeofizike per kerkimin e

drejtperdrejte te shtratimeve te naftes e gazit, duke futur metoden e fushes elektrike natyrore, metoden e gradientit te P.S. (Alfred Frashëri, Rushan Liço, etj. U bene perpjekjet e para per kryerjen e punimeve gjeofizike ne det me inisiativen dhe nen drejtimin e Ing. Hasan Topçiut, dhe u arrit qe megjithese me nje metodike relativisht te prapambetur , te filloje kryerja e punimeve gjeofizike ne det, ndermjet te cilave edhe punimet sizmike, duke ngritur per kete qellim edhe strukturat administrative perkatese. U organizua ekspedita komplekse gjeologjikegjeofizike detare qe kryente punime gjeologjike, gjeofizike dhe te shpimit te ceket sidomos per studimin e shelfit detar te Adriatikut. Rezultat i punimeve e studimeve te kryera qe projektimi i pusit Durresi – 16, i cili arriti të zbulojë shtratimin e gazit nw det nw strukturën e Durresit.

Duke ndjekur arritjet e shkences boterore ne keto fusha si nepermjet literatures, ashtu dhe te ndonje pervoje direkte te marre nepermjet vajtjes se specilisteve jashte shtetit, u shtruan probleme te rendesihme ne drejtim te regjistrimit dhe perpunimit te materialeve sizmike. Keshtu u sigurua rritja e kapacitetit perpunues te qendres elektronike te perpunimit dhe u shtrua me me force kerkesa per sigurimin e aparaturave me regjistrim shifror. Ne fundin e viteve ’70 dhe fillimin e viteve ’80 u siguruan aparatura me regjistrim shifror 48 kanaleshe te tipit SN-338 dhe me vone edhe stacione me 96 kanale, madje edhe stacion telemetrik. Keto masa dhe kembengulja e specialisteve bene qe te punohet mjafte ne drejtim te permiresimit te cilesise se materialeve sizmike, duke ndermarre disa dhjetra tema studimi e projektimi si ne drejtim te metodikes fushore duke rritur shkallen e mbulimit shume fish deri ne 48 here e me teper, te perpunimt dhe sidomos te interpretimit te te dhenave, duke futur metodika te reja ne terren, hartuar programe te reja perpunimi ne perputhje me kushtet konkrete te vendit dhe ne interpretimin e tyre duke futur modelimin, llogaritjen e sizmogramave sintetike etj.

Ne kete kohe u zgjerua edhe bashkepunimi i Katedres se Gjeofizikes me institutin e naftes dhe me Ndermarrjen Sizmogravimetrike qe tashme ishte ndare si njesi me vehte. Gjate viteve ’80 krahas pergatitjes e kualifikimit te disa kuadrove jashte shtetit, u organizua kualifikimi i tyre brenda vendit qofte nepermjet kurseve ashtu dhe nepermjet kualifikimit pasuniversitar. Ne fushen e sizmikes u pergatiten disa disertacione per shkallen e pare te kualifikimit, drejtimi shkencor i te cilave u be kryesisht nga pedagoget e katedres se gjeofizikes në të cilat trajtoheshnin probleme te metodikes se kryerjes, perpunimit dhe interpretimit të tv dhënave sizmike, mbrojten disertacinone ne fushen e sizmikes Teki Biçoku (1962), dhe në vitet tetëdhjetë Petref Nishani ,Vilson Bare, Vangjel Jani, Ali Mema, Çaush Xhufi, Stavro Dhima, Vullnet Xhango, Theodhori Kamberi, Vilson Silo etj.

Arritjet e shkences ne fushat perkatese, shpreheshin edhe ne pasurimin e permiresimin e planeve e programeve mesimore te lendeve qe zhvilloheshin ne degen e gjeofizikes, madje ne disa raste duke i paraprire venies se tyre ne praktike. Keshtu u futen lendet
teknika llogaritese (informatika), perpunimi dhe trajtimi i sinjalit, programimi ne gjeofizike, elementet e stratigrafise sizmike dhe zbatimi i tyre ne praktike. Mbi bazen e futjes ne interpretimet e te dhenave sizmike te koncepteve te stratigrafise sizmike dhe te sedimentologjise dhe ne perputhje me to edhe te rritjes se kerkesave ndaj perpunimit te materialeve sizmike, krahas marrjes se programeve te perpunimt nga jashte, ne qendren e perpunimit u hartuan edhe programe speciale te perpunimit dhe sidomos ne drejtim te perpunimit me ruajtje amplitude, pati edhe arritje ne zgjerimin e disa vendburimeve ekzistuese te naftes e gazit dhe ne zbulimin e shtratimeve te reja sidomos te gazit si ne Veri te Divjakes, Ballaj- Kryevidh, Povelçe, Panaja etj. ku interpretimet mbi bazen e koncepteve te stratigrafise sizmike te zbatuara nga specialistet Vangjel Jani, Vullnet Xhango etj. zune vend te rendesishem dhe dhane edhe rezultatet e priteshme.

Nga fundi i viteve '80 katedra e gjeofizikes ne kuadrin e projekteve te UNESCO-s u pajis me nje aparature sizmike 12 kanaleshe e cila u perdor kryesisht ne studimet e ceketa, inxhinierike.
Ndryshimet demokratike te viteve '90 sollen ndryshime te rendesishme edhe ne sektorin e sizmikes. E drejta e kryerjes se punimeve sizmike dhe e kerkimit te naftes e gazit ne det iu dha kompanive te huaja. Me ndihmen e tyre pati nje fare permiresimi sidomos te qendres se perpunimit te te dhenave, duke zgjeruar kapacitetin e saj nepermjet shtimit te paisjeve e sidomos te programeve te perpunimit, ose paisja me Land- Marc ne ndihme te interpretimit te te dhenave. Pati nje rritje te aktivitetit referues e botues te studimeve te kryera nga specialistet, u rrit pjesemarrja ne aktivitetet shkencore kombetare e nderkombetare duke u paraqitur me dhjetra referate, kumtesa e postera ne konferenca e kongrese nderkombetare te gjeologjise dhe gjeofizikes.

Me vone, sidomos pas vitit 1997, kur pati edhe nje largim thuajse masiv te specialisteve, vellimi i punimeve fushore ra ne zero, duke mbetur ne nje vellim te kufizuar perpunimi i materialeve te vjetra ose perpunimi paraprak i materialeve te kompanive te huaja, gje tani ka rene thuajse ne zero.

Ne periudhen pas viteve '90 u bene perpjekje per perdorimin e sizmikes ne zgjidhjen e detyrave ne fusha te tjera te gjeologjise si ne gjeologjine inxhinierike, ne studimin e monitorimin e veprave ne shfrytezim etj. ne kuadrin e disa projekteve si te hartes gjeologo inxhinierike te Shqiperise, studimit insitu te veprave, studimit te rreshqitjeve etj., por megjithe rezultatet pozitive me interes të zgjidhjeve e ndihmesës së dhënë prej tyre, mungesa e projekteve te metejshme dhe sidomos zbatimi i nje politike jo të mjaftueshme ne

qendrimet ndaj vlerësimit të ketyre punimeve, bene qe ato te mbeten pa e gjetur vendin emerituar në përputhje me rëndësinë që ato duhet të kenë në zgjidhjet që ofrojne për ekonominë.

Si perfundim historine e zhvillimit te punimeve sizmike mund ta ndajme ne kater etapa kryesore.

1. Etapa 1952-1970, kur u perdor regjistrimi oshilografik, metodike relativisht e thjeshte, me thellesi studimi relativisht te vogel, perpunim dhe ndertim me dore i materialeve sizmike. Punimet në këtë periudhë u kryen kryesisht ne terrene fushore.

2. Etapa e dyte 1969- 1978. Regjistrim magnetike analog. Perpunim laboratorik i materialit, fillimisht analog, me pas shifror (digital). Ndryshime et rendesishme te metodikes fushore, perdorimi i mbulimit shumefish, rritje e diapazonit dinamik te regjistrimit. Futja ne terrene me ndertim te nderlikuar siperfaqesor dhe ne thellesi.

3. Etapa e trete 1980 –1990. Regjistrim dhe perpunim shifror i materialeve sizmike, rritje e metejshme e diapazonit dinamik te rregjistrimit, rritje e cilesise dhe thellesise se studimit, perdorim gjeresisht i metodikes se mbulimit shumefish, rritje e fishmerise, thellim ne perpunimin e materialeve.

4. Periudha e viteve ’90 e me pas. Renie gradualisht deri ne zero e punimeve per kerkimin e naftes. Renie graduale e vellimit te perpunimit te materialeve te vjetra. Interpretime dhe riinterpretime te materialeve te vjetra me pak riperpunime te tyre. Kryerje punimeve nga kompani te huaja.
Gjate kesaj periudhe po behen perpjekje per perdorimin e sizmikes ne fusha te tjera te gjeologjise, si ne gjeologjine inxhinierike, ndertim etj.

2. STUDIMET SIZMOLOGJIKE

Shërbimi sizmologjik shqiptar së bashku me atë game studimesh që përfshin, nuk ishte një godinë e ngritur më kot e pa themel. Ai do të sintetizonte përvojën popullore të një bashkësie njerëzish që e kanë njohur brez pas brezi tërmetin, atë mençuri të thjeshtë që shprehet qoftë në zgjedhjen e trojeve të fortë për ndërtim ashtu dhe në përfshirjen në mure të brezave të drunjtë. Ai do të ngrihej gjithashtu mbi të dhënat e përcjella gojë më gojë apo të shënuara në dokumente të ndryshme nga njerëz të thjeshtë pasionantë apo dijetarë të fushave të çfardoshme. Shumica e këtyre të dhënave sidomos ato mbi tërmetet e ndodhur në vendin tonë në lashtësi e në mesjetë, ndodhen në bibliotekat dhe kancelaritë e Evropës. Një pjesë e madhe e tyre sot ka dalë në dritë. Deri në fillimet e shekullit XX nuk ka studime të veçanta mbi tërmetet e trojeve shqiptare. Por në disa nga studimet e kryera

prej dijetarëve natyralistë të ndryshëm. Lidhur me tërmetet e Ballkanit apo Evropës jepen edhe të dhëna mbi tërmetet e forte që kanë prekur Vlorën, Beratin, Shkodrën, Elbasanin etj. në shekullin XIX.

Një periudhë e re nisi për shkencën e sizmologjisë me fillimin e shekullit XX. Kjo qe rezultati i ngritjes në Evropë të stacioneve të pare sizmologjike, gjë që bëri të mundur regjistrimin dhe interpretimin e ngjarjeve më të rëndësishme sizmike të kontintentit dhe botës. Fillimi i kësaj periudhe shënon në fakt lindjen e sizmologjisë si shkencë më vete, në përbërje të shkencave të Tokës, shkencë që studion tërmetet, përhapjen e valëve të tyre dhe pasojhat në sipërfaqe. Që nga kjo kohë, interesimi i dijetarëve të huaj për tërmetet që preknin tokën shqiptare u rrit edhe më. Kjo shprehet në studimet e kryera mbi termete të veçantë të vendit tone si dhe mbi sizmicitetin e Shqipërisë në përgjithësi.

Vëmendjen e studiuesve të huaj e tërhoqi sidomos tërmeti i fuqishëm i 1 qershorit 1905 me epiqendër pranë Shkodrës, tërmet për të cilin janë shkruar disa raporte e studime. Është interesante të vemë në dukje se në fototekën Marubi në Shkodër, ekzistojnë 40 copë negative fotografish që paraqesin objekte të dëmtuara nga tërmeti në fjalë. Këto fotografi që kanë për autor fotografin e talentuar shqiptar Kel Marubi, e ruajnë vlerën e tyre njohëse e shkencore edhe sot. Të rralla janë në botë deri në atë kohë raste tërmetesh të dokumentuar me fotografi si tërmeti i Shkodrës i vitit 1905.

Studime nga shkencëtarë të huaj janë kryer edhe për tërmetet e vitit 1930 që prekën rrethin e Vlorës te vitit 1931 te Korces etj. Duhet thënë se me fillimin e regjistrimeve instrumentale nisi edhe botimi sistematik i buletineve sizmologjike si nga observatorë të ndryshëm të Evropës, ashtu edhe nga Qendra Sizmologjike Ndërkombëtare (International Seismological Centet) ne Angli dhe nga Byroja Qendrore Ndërkombëtare e Sizmologjisë (BCIS) në Strasburg të Francës. Në këto buletine përfshihen dhe tërmetet e rënë gjatë shekullit te XX-te në vendin tonë dhe rreth tij. Të dhëna për to gjenden edhe në katalogët e ndryshëm të përpiluar nga studiues evropianë në të cilët përfshihen tërmetet e fortë të Evropës apo të të gjithë botës.

Sidoqoftë studimet e ktyera mbi sizmicitetin e Shqipërisë deri në përfundimin e Luftës së Dytë Botërore dhe çlirimin e vendit janë të pakta dhe të kryera nga shkencëtarë të huaj. Studime përgjithësuese kanë kryer sizmologët jugosllavë J. Mihajllovic (1927) dhe D. Mihajllovic (1951), si dhe italiani K. Moreli (1942). J. Mihajllovic dhe K. Moreli kanë dhënë dhe harta të rajonizimit sizmik të territorit të vendit tonë. Materiali në të cilin janë bazuar këto harta nuk është i homogjenizuar në hapësirë dhe kohë, shpesh here ka ekzagjerime e pasaktësira. Mjaft tërmete kufitarë janë konsideruar si autoktone dhe në përgjithësi ka mbivlerësime të intensiteteve të tërmeteve.

Mbas çlirimit të vendit si kudo në ekonomi, shkencë edhe studimit të tërmeteve dhe të sizmicitetit të Shqipërisë do t'i dilnin për zot specialistë shqiptarë të cilët gradualisht, por me kurajo e siguri do të futeshin në të panjohurat që nëntoka shqiptare fshihte me tërmetet. Shqipëria e re e drobitur dhe e dëmtuar nga lufta, por me vullnet e pasion kishte plot plane ndërtimore. Por gjithçka do të ngrihej mbi një truall që i njihte dhe i kishte provuar lëkundjet nëntokësore. Ndaj studimet sizmologjike merrnin vlerë e rëndësi të veçantë. Menjëherë sapo nisi rindërtimi i vendit specialistët e Ministrisë së Ndërtimit dhe të ish Institutit të Shkencave u ngarkuar me detyrën e studimit mbi përpilimin e hartës sizmike të Shqipërisë dhe të dispozitave mbi ndërtimet antisizmike. Në vitin 1952 specialistët e ngarkuar me këtë detyrë paraqitën hartën e parë sizmike të Shqipërisë në shkallën 1:1.350.000 si dhe dispozitat e para që do të zbatoheshin në ndërtimet sizmike. Studimi dhe dispozitat u miratuan nga Këshilli i Ministrave në dhjetor të po atij viti. Kjo hartë sizmike u përpilua duke u bazuar në të dhënat sizmologjika që jepnin autorë të huaj të mëparshëm si dhe me materialin që u mblodh në vend për këtë qëllim nga shtypi i kohës etj. Në të u muar parasysh edhe kualiteti i ndërtimeve të vendit tonë. Ndërsa dispozitat e para për ndërtimet antisizmike u kryen duke patur si bazë teorinë statike.
Përpilimi i hartës sizmike të Shqipërisë të vitit 1952 ishte një sukses i shkencës sonë të re të viteve të para të pasçlirimit. Kjo hartë me pak ndryshime mbeti në fuqi deri në vitin 1979. Vetë procedura e punës për përpilimin e saj nxori si domosdoshmëri studimin dhe evidentimin e çdo tërmeti të fortë që do të binte në territorin e vendit tonë. Nisur nga kjo Shërbimit Gjeologjik të vendit tonë dhe specialistëve të Ministrisë së Ndërtimit iu ngarkua detyra që të kryenin studime për çdo tërmet dëmtues të vendit. Veç kësaj Shërbimi Hidrometeorologjik mori përgjegjësinë e evidentimit të çdo lëkundjeje të ndjeshme nëpërmjet vrojtuesve të tij të shpërndarë në të gjithë vendin, me anën e fletëanketave të posaçme të përpiluara nga ky shërbim.
Tërmetet e fortë të 3 prillit 1958 (Durrës), të gusht-shtatorit 1959 (Lushnje, Berat, Fier), të 26 majit 1960 (Korçë) dhe të 18 marsit 1962 (Fier), u studiuan nga specialistët tanë, të cilët kryen vrojtimet fushore dhe përpiluan raportet përkatëse duke dhënë një material makrosizmik me interes dhe rekomandime të vlefshme për ndërtimet antistizmike të vendit. Mjaft studime fushore e raporte janë kryer nga specialistët Anesti Lubonja, Eshref Pumo, Ligor Lubonja, Luan Peza, Vangjel Melo, Vedat Shehu etj. Në fushën e ndërtimeve antisizmike në vendit tonë kontribut të rëndësishëm dhanë Cefo Fico, Vasil Pistoli, Ferit Stërmasi, Anthim Konomi, Rifat Bodinaku, Spiro Vjero etj. Ishin pikërisht studimet dhe rekomandimet përkatëse të të gjithë këtyre specialistëve ato që çuan në korigjimet e hartës sizmike të vitit 1952, duke përfshirë në zonën 8 ballëshe rrethin e Fierit. Gjithashtu u

përpiluan dispozitat e reja antisizmike të bazuara tashmë në teorinë dinamike, dispozita të cilat ishin një hap i madh përpara në krahasim me të parat. Ato së bashku me ndryshimet e bëra në hartën sizmike u miratuan nga Këshilli i Ministrave me vendimin nr. 206, dt. 04.06.1963 – "Mbi aprovimin e rregullores mbi kushtet teknike për ndërtimet antisizmike dhe ngritjen e shërbimit sizmologjik në vendin tonë". Po me anën e këtij vendimi u vendos ngritja në Tiranë e një stacioni sizmik të tipit të përgjithshëm për regjistrimin e tërmeteve të afërt e të largët. Kjo do të shënonte dhe ngritjen e Shërbimit Sizmologjik shqiptar. Për zbatimin e këtij vendimi Këshilli i Ministrave me shkresën nr. 27/161 dt. 10 korrik 1964 ngarkoi Universitetin Shtetëror të Tiranës, detyrë të cilën e mori përsipër Fakulteti Gjeologji Miniera. Menjëherë pas kësaj në këtë fakultet u krijua një bërthamë e përbërë nga Ligor Lubonja dhe Eduard Sulstarova e cila do të ishte përgjegjëse për organizimin dhe ngritjen e Shërbimit Sizmologjik të Shqipërisë dhe në këtë kuadër edhe Stacionit Sizmologjik të Tiranës.
Ishte pikërisht kjo bërthamë që filloi menjëherë nga puna për mbledhjen dhe sistemimin e të gjitha studimeve sizmologjike si dhe mbledhjen e të dhënave mbi tërmetet e vendit tonë. Ndërkaq ishte kryer një punim përgjithësues tepër modest mbi tërmetet e Shqipërisë. Kjo ishte një punë diplome e inxhinierit Eduard Sulstarova "Tërmetet e Shqipërisë" 1963. Bërthama e ngritur pranë Fakultetit të Gjeologjisë e Minierave, botoi në vitin 1964 studimin "Disa mendime mbi sizmicitetin e RP të Shqipërisë dhe thellësinë e vatrave të disa tërmeteve" (L. Lubonja dhe E. Sulstarova, Buletini i Shkencave të Natyrës, nr. 3, 1964).
Në këtë kohë në vendin tonë nuk kishte asnjë kuadër të sizmologjisë të përgatitur në mënyrë të posaçme që të mund të kryente studime të mirëfillta e me nivel në këtë fushë. Nuk kishte gjithashtu asnjë lloj përvoje mbi organizimin, funksionimin e një stacioni sizmologjik, manipulimin e aparaturave të tij, si dhe përpunimin e regjistrimeve sizmologjike. Kjo bëri të domosdoshme dërgimin për specializim të dy kuadrove jashtë shtetit. Këta dy specialistë (Eduard Sulstarova dhe Siasi Koçiaj) pas kthimit nga Instituti Gjeofizik i Akademisë së Shkencave të RP të Kinës, në mars 1966 filluan punën për zgjedhjen e vendit ku do të ngrihej stacioni sizmologjik i Tiranës. Kjo kërkonte një studim të kujdesshëm të vendit ku do te nderohej stacioni sizmologjik, i cili duhet te ndertohej ne troje te forte si dhe larg zhurmave industriale dhe te trafikut . Si vend më i përshtatshëm për këtë qëllim u gjet ai në zbritje të kodrave të Linzës. Në një lartësi 196.8 m mbi nivelin e detit në lindje të sinklinalit të Tiranës, mbi formacionet e ranoreve të cimentuar të Tortonianit, të cilët dalin në sipërfaqje dhe që kanë trashësi disa qindrametra.
Ndërkaq nuk u la mënjanë puna për mbledhjen dhe sistemimin e çdo materiali që kishte të bënta me tërmetet e vendit tonë dhe sizmicitetin

e tij. U kryen gjithashtu disa ekspedita fushore në vitet 1966-1967. Seria e tërmeteve të maj-gushtit 1966 (Fterë-Sarandë), tërmeti i 9 shkurtit 1967 në Selo (Gjirokastër) dhe tërmeti i fuqishëm i 30 nëntorit 1967 (Dibër) u studiuan në të gjitha aspektet e tyre nga Eduard Sulstarova dhe Siasi Koçiaj. Këto tërmete dhanë një material të bollshëm sizmologjik, i cili do të bëhej bazë e shumë studimeve të mëvonshme.

Detyra e projektimit të të parit stacion sizmologjik të Shqipërisë, stacionit sizmologjik të Tiranës, iu ngarkua Fakultetit të Inxhinierisë. Arkitekti i tij ishte inxh. Vasilika Cicko. Ndërtimi i godinës së stacionit nisi në fund të vitit 1966 dhe përfundoi në fillim të vitit 1968; Në stacion u vendos një komplet sizmografësh i tipit të përgjithshëm SSJ-1, sizmograf, periudhë-mesëm me karakteristika frekuenciale siç paraqiten në fig. 1. Montimi i tij kërkoi një punë të kujdesshme dhe mjaft të saktë gjatë gjysmës së parë të vitit 1968. Aparatura u vendos mbi një postamend betoni sipas të gjitha kushteve që kërkoheshin më pikën me koordinata 41^0 20.8' V e 19^0 52' L dhe lartësi 196.8 m mbi nivelin e detit, të cilat do të ishin këtej e tutje edhe koordinatat e të parit stacion sizmologjik të vendit tonë.

Stacioni sizmologjik i Tiranës nisi regjistrimin e tij të vazhdueshëm për të mos u ndërprerë më kurrë më 1 korrik 1968 datë që me të drejtë shënon edhe ngritjen e Shërbimit Sizmologjik shqiptar. Pas kësaj date studimeve tona sizmologjike u vihej në dispozicion një mjet i fuqishëm dhe i domosdoshëm ato dhjetra qindra, mijra e dhjetramijra sizmograma që do të vinin duke u rritur vazhdimisht e që do të përmbanin brenda tyre informacionin e vlefshëm të regjistrimit të tërmeteve tanë. Tani mund të gjykohej me kompetencë si për vendndodhjen ashtu dhe për magnitudën e tërmeteve të ndjeshëm në vendin tonë.

Duhet theksuar se ngritja montimi dhe vënia në punë e stacionit sizmologjik të Tiranës ishte rezultat i këmbënguljes dhe pasionit të punonjësve të parë të tij si dhe e gjithë atyre që ndihmuan në të. Ai u ngrit, u montua dhe u përvetësua krejtësisht prej specialistëve tanë.

Për historinë e regjistrimeve sizmologjike në Shqipëri do të mbetet e shënuar data 25 korrik 1968 kur në orën 22 05 (GMT) në Stacionin Sizmologjik të Tiranës u regjistrua i pari tërmet me epiqendër në vendin tonë. Ky tërmet u lokalizua në koordinatat 41.1 V dhe 20.2 L, kishte magnitudë M=4.5 shkalla e Rihterit dhe intensitet 6 ballë MSK-1964. Ai u ndje fort në zonën e Shpatit, Elbasan. Ndërsa më 1 gusht 1968, në orën 20 19 (GMT), u regjistrua një tërmet i fuqishëm me epiqendër 16^0.4 V, 122^0.2 L, pranë Maniles (Filipine), me magnitudë M=7.5. Ky ishte i pari tërmet i largët që u interpretua me saktësi nga specialistët tanë.

Fillimi i regjistrimit sistematik instrumental të ngjarjeve sizmike ishte e natyrshme që do të shënonte hop cilësor në studimet sizmologjike të

vendit tonë. Puna e nisur që nga viti 1963 për mbledhjen dhe përpunimin e të dhënave sizmologjike shkoi shumë përpara. U shfrytëzuan arkivat e vendit, shtypi i kohës, kronikat e ndryshme, literatura përkatëse sizmologjike ku gjendeshin të dhëna edhe mbi tërmetet e Shqipërisë, dëshmitë gojore të mbledhura gjatë ekspeditave fushore etj. Në fund të vitit 1972 u mblodhën në Observatorin Sizmologjik të Shkupit të gjitha regjistrimet e rrjetit sizmologjik jugosllav që kishin të bënin me tërmetet e territorit tonë, kurse në fillim të vitit 1973 një punë e tillë lidhur me regjistrimet e rrjetit sizmologjik evropian dhe atë botëror u krye në arkivin sizmolgojik të Byrosë Qendrore Ndërkombëtare të Sizmologjisë në Strasburg të Francës.
Me materialet e grumbulluara qoftë nga arkivat qoftë nga ekspeditat në terren, u bë e mundur që të krijohet një përfytyrim më i drejtë mbi tërmetet e ndodhur në të kaluarën në vendin tonë, u rivlerësuan intensitetet dhe epiqendrat e tyre shpesh herë të pasakta, duke rindërtuar një tablo më reale të sizmicitetit të Shqipërisë deri në atë kohë.
Stacioni Sizmologjik i Tiranës ishte nga viti 1968 deri në fund të vitit 1972, në varësi të Katedrës së Gjeofizikës të Fakultetit Gjeologji-Miniera, katedër që drejtohej nga Doc. Ligor Lubonja. Gjatë kësaj periudhe ky stacion përbëhej nga 8 kuadro, nga të cilët 3 të larta, bashkëpunëtorët shkencorë Eduard Sulstarova, Siasi Koçiaj, Shyryqi Aliaj (Shyqyri Aliaj ishte emëruar si bashkëpunëtor shkencor në Stacionin Sizmologjik të Tiranës në vitin 1969, për studimet sizmotektonike) dhe 4 të mesëm laborantët Nazmi Hida, Kristaq Çollaku, Haki Elbasani e Bardhyl Tepelena dhe një roje Seit Bastari.
Në vitet 1968-1972 u kryen mjaft ekspedita fushore duke e shkelur thuajse gjithë vendin. Këto ekspedita u kryen si për mbledhjen e materialit makrosizmik të tërmeteve të fortë të ndodhur më parë dhe për të verifikuar të dhënat që disponoheshin, ashtu dhe për studimin e kushteve gjeologjike të lindjes së tërmeteve në vendin tonë.
Nga ana tjetër, duke njohur rëndësinë e madhe të shkëmbimit të të dhënave sizmologjike me stacionet dhe institucionet e huaja sizmologjike, me qëllim të përpunimit dhe saktësimit të mëtejshëm të parametrave të vatrave të tërmeteve që ndodhin tek ne që në gusht 1968, me anën e një letre, iu bë e njohur ngritja e Stacionit Sizmologjik të Tiranës mjaft institucioneve të huaja si dhe Byrosë Qendrore Ndërkombëtare të Sizmologjisë (BCIS, nga viti 1976 Qendra Sizmologjike e Evropës Mesdhetare) në Strasburg, Francë dhe Qendrës Ndërkombëtare të Sizmologjisë në Angli. Nga këto institucione kërkohej shkëmbimi i buletineve sizmologjike dhe i studimeve.
Në shtator 1968 filloi në Stacionin Sizmologjik të Tiranës përpilimi i raporteve paraprake javore të leximit të sizmogramave të përftuara. Këto të dhëna dërgoheshin kryesisht në Strasburg. Kjo Qendër

ndërkombëtare pasi grumbullon të dhënat e të gjithë rrjetit sizmologjik evropian jep me anën e buletimeve të veçantë parametrat e tërmeteve si dhe referon agjensitë e marra në konsideratë për përcaktimet e kryera. Duhet përmendur se ishte kënaqësi të shihje në përcaktimet që dërgonte BCIS mes dhjetra stacionesh sizmologjike edhe stacionin tonë të ri. Emërtimi TIR i këtij stacioni e më pas Qendër Sizmologjike do të zinte vend me dinjitet në këto raportime si dhe në mjaft të tjera buletine e referenca ndërkombëtare. Kjo gjë e forcoi edhe më besimin e kolektivit të vogël e të ri të stacionit tonë të parë sizmologjik.
Po këtë vit filloi përpilimi dhe botimi i buletineve sizmologjike paraprake mujore, si dhe një botim periodik në dy gjuhë, shqip e anglisht. I pari buletin i këtij lloji është ai i shtatorit 1968.
Është meritë e punonjësve të parë shkencorë të këtij institucioni të ri që e orientuan punën jo thjesht në anën rutinore por doradorës e bënë Stacionin Sizmologjik të Tiranës një institucion kompetent për gjithçka kishte të bënte me sizmologjinë e Shqipërisë. Gjatë kësaj periudhe u hartuan mjaft relacione, raporte e studime si për tërmete të veçantë ashtu dhe për sizmicitetin e Shqipërisë në përgjithësi. Në këto të fundit mund të përmenden studimet sintezë:
Harta e rajonizimit sizmik të Shqipërisë në shkallën 1 : 2 500.000 (Sulstarova, E., Koçiaj, S., Aliaj, Sh.), e cila u dërgua edhe për përpilimin e hartës sizmike të Evropës,
Harta sizmike e Shqipërisë në shkallën 1 : 1 250.000 (Sulstarova, E., Koçiaj, S., Aliaj, Sh., 1972) e cila shërben për marrjen e masave antisizmike për ndërtimet e veprave më të rëndësishme që u ndërtuan në periudhën 1972-1979 (kryesisht hidrocentrale dhe veprat më të rëndësishme industriale),
Harta sizmotektonike e Shqipërisë në shkallën 1 : 1 00 000 (Aliaj, Sh., Koçiaj, S., Sulstarova, E., 1973).
Në studimet e mësipërme u paraqitën përfytyrimet më të reja, deri në atë kohë, mbi sizmicitetin e Shqipërisë duke nxjerrë në pah edhe mjaft karakteristika të aktivitetit sizmik si dhe duke evidentuar kriteret më të rëndësishme gjeologjike të rrezikut sizmik. Këto studime hodhën dritë edhe mbi mjaft elemente të ndërtimit gjeologjik të vendit tonë dhe u bënë baza e mjaft studimeve të tjera më të hollësishme e komplekse që i pasuan.
Më pas me dekretin 4993 dt. 10.10.1972 u krijua Akademia e Shkencave e Shqipërisë, si institucioni më i lartë shkencor i vendit. Mbi bazën e Stacionit Sizmologjik të Tiranës të Fakultetit Gjeologji – Miniera në përbërjen e Akademisë së Shkencave si institucion kërkimor shkencor më vete u ngrit Qendra Sizmologjike. Asaj iu vu detyre të organizonte e të kryente studime mbi sizmicitetin e Shqipërisë në të gjitha aspektet me qellim sqarimin e natyres së termeteve, të zbulojnë ku kanë lindur e ku mund të lindin ata në të ardhmen, të përcaktojnë fuqinë e tyre dhe të bëjnë rajonizimin e

mikrorajonizimin sizmik, të japin kritere tekniko-ekonomike për projektimet antisizmike etj. Detyrë kryesore që u vu menjëherë me ngritjen e saj ishte realizimi i studimeve komplekse për rajonizimin sizmik të vendit në shkallën 1 : 500 000.

Ne vitin 1979 u realizua studimi me i rendesishem ne fushen e sizmologjise te viteve 70-te “Rajonizimi Sizmik i RPS te Shqiperise “ (shqip , anglisht) se bashku me Harten Sizmike ne shkallen 1:500.000 (autore: E.Sulstarova, S.Kociu dhe Sh.Aliaj), i cili deri sot sherben si kusht normativ per te gjitha ndertimet antizimike qe behen ne vendin tone si dhe eshte baze per te gjitha studimet inxhinero-sizmologjike per mikrozonimin simik te qendrave te banuara si dhe studimit te shesheve ku ndertohen vepra te rendesishme. Ky studim e thelloj njohjen mbi sizmicitetin e vendit tone dhe tregoi se Shqiperia hyn ne vendet me aktivitet me te theksuar ne Evrope.

Ne fushen e sizmicitetit te Shqiperise ne teresi dhe te zonave te vecanta, ne ate sizmotektonike dhe te neotektonikes jane realizuar, gjate kesaj peridhe, shume studime sinteze me shume rendesi; gjithashtu jane realizuar studimene fushen e mekanizmit te vatrave dhe lidhur me te te fushes se sforcimeve tektonike, te sizmicitetit te induktuar nga ngritja e rezervuareve te H/C te medhenj mbi lumin Drin, disa kataloge termetesh me i rendesishmi e me i ploti“ Katalogu i Termeteve te Shqiperise – 1975 –autore: E.Sulstarova, S.Kociu, i cili permban te dhena te perpunuara per termetet nga shekulli i III –para eres se re deri ne vitin 1970 se bashku me shume harta izosejstesh; jane botuar ne shtypin shkencor vendas dhe te huaj per termete te vecante shume studime e artikuj shkencore.

Ne fushen e sizmologjise inxhinerike, me specializimin e kuadrit shkencor jashte vendit ne periudhen 1977-1978 filluan studimet komplekse inxhinero-sizmologjike dhe gjeologo-inxhinerike per mikrozonimin sizmik te qendrave te banuara. U realizuan deri ne vitin 1991 studime komplekse inxhinero sizmologjike dhe inxhinero-gjeologjike per mikrozonimin sizmik ne shkallen 1:10.000 te qyteteve: Vlore, Durres, Shkoder, Tirane, Pogradec, Korce dhe Fier. Pas viteve 1990 u realizuan studime te kesaj natyre edhe per hapesiren Tirane – Durres dhe studime me te detajuara ne pjese qendrore te Durresit, per zbulimin e shtreses arkeologjike. Keto studime u realizuan ne bashkepunim te ngushte me Fakultetin e Gjeologjise dhe Minierave, dhe me ish ndermarrjet Gjeologji-Gjeodezi, Hidrogjeollogji ne Tirane dhe ndermarrjet Gjeofizike ne Patos dhe ate Gjeofizike Komplekse per kerkimin e naftes e gazit ne Fier.

Ne vitn 1982 u ngrit ne Qendren Sizmologjike edhe sektori i inxhinerise se termeteve, i cili u ngarkua me studimin e sjelljes se strukturave dhe te objekteve te ndryshem ndertimore ndaj veprimit dinamik te termeteve, adaptimit te kritereve tekniko-ekonomike per projektimin antisizmik si dhe hartimin e metodikave te llogaritjes ne

sizmicitet te strukturave te tipeve te ndryshem dhe bashke me to dhe me hartimin e kushteve te reja teknike te projektimit ne zonat sizmike. Nen udheheqjen e ketij sektori dhe ne bashkepunimim me pedagoge te Unuveritetit te Tiranes dhe specialiste te institucioneve studimore dhe projektuese te ish Ministrise se Ndertimit u realizua hartimi i " Kushteve teknike te projektimit ne zonat sizmike KTP-N.2-89, i cili pas rreth dy vjet eksperimentimi dhe vleresimi hyri ne fuqi ne vitin 1991 dhe sherben deri sot, se bashku me Harten e Zonimit sizmik ne shkallwen 1:500.000, si kusht normativ i domosdoshem per projektim dhe ndertim ne zonat sizmike. Ne fushen e inxhinerise se termeteve u realizuan shume studime e raporte teknike per sjelljen e objekekteve gjate veprimit te termeteve si dhe u bene mjaft eksperimenete per studimin e sjelljes se objekteve dhe strukturave nga vibrimet natyrore duke perdorur teknika bashkohore te studimit te vibrimeve- tipin VSS-1.
Sikunder theksuam me siper Stacioni i pare Sizmologjik i Shqiperise u ngrit ne vitin 1968; ai u pajis vetem me nje sizmograf periudhe mesem i tipit SSJ- prodhim i Jenes ne Gjermani. Ne vitin 1973 Stacioni i Tiranes u kompletua edhe me nje sizmograf periudhe shkurter tipi DDJ-1, prodhim i Akademise se Shkencave te Kines, ndersa ne vitin 1975 ai u pajis edhe me dy sizmografe te tjere- njeri tre komponentesh, periudhe shkurter, tip SS-1 dhe tjetri periudhe gjate i tipit Spregnether LP-S-5100 (H+V), si dhe nje akselerograf tipi SMA-1; te gjitha prodhime te Shteteve te Bashkuara te Amerikes . Ne vitin 1987 u instalua edhe nje sizmoskop tipi VM-2. Kompletimi i Stacionit Sizmologjik te Tiranes edhe me aparaturat e me siperme e ktheu ate ne nje stacion sizmologjik te klasit te pare, i afte per te regjistrar gjithe diapazonin e termeteve te afert e te larget, dhe per rrjedhoje ai sherben edhe sot si Stacion Sizmologjik Qendror per Shqiperine, ku sherbimi realizohet per 24 ore. Nga viti 1987 Stacioni Qendror Sizmologjik i Tiranes u konsiderua si njesi me vehte brenda rrjetit sizmologjik.
Per te rritur aftesine detektuese ndaj termeteve dhe saktesine e percaktimit te parametrave te tyre ne vitin 1975 filloj te ngrihet Rrjeti Sizmologjik i Shqiperise , i cili ne fund te vitit 1986 numeronte 13 stacione te gjithe te pajisur me nga nje komplet simografesh peridhe shkurte trekomponentesh tipi DDJ-1, me nga nje akselerograf te tipit SMA-1 dhe nje sizmoskop tipi WM-2.

Rrjeti sizmologjik i Shqiperise perbehet nga keto 13 stacione (Tiranë, Shkodër, Vlorë, Bajram Curri, Pukë, Korçe, Peshkopi, Sarandë, Kukës, Berati, Tepelenë, leskovik dhe Laç.
Stacionet e rretheve u vendosen ne godina te reja te ngitura posacerisht ne te cilat ne katin e pare ishin vendosur aparaturat regjistruese; ne nje ambient te vecante, ne bodrume ose tunele te

aferta, sizmografet , ndersa ne katin e dyte familja e personit qe punonte ne stacionet e rretheve.
Rrjeti Sizmologjik i Shqiperise eshte ne gjendje te detektoje e te regjistroje me saktesi te kenaqeshme te gjitha ngjarjet sizmike qe ndodhin ne vendin tone dhe rreth nesh me magnitude M >=2,5 skalla e Rihterit. Niveli i detektimit ne stacione te vecante eshte mjaft i larte; cdo stacion eshte ne gjendje te detektoje termete me magnitude rreth zeros te shkalles Rihter.
Rrjeti sizmologjik i Shqiperise eshte perfshire ne rrjetin boteror te Sizmologjise dhe te dhenat tona raportohen ne Buletinet e Qendrave Nderkombetare ne Strasburg (France), nga Qendra Nderkombetare Sizmologjike ne Angli, ISC, nga Agjensite e SHBA. NEIS etj. Ky rrjet detekton gjithe termete e globit me magnitude mbi 4 shkalla Rihter.
Pervec Rretit Sizmologjik te Shqiperise, nga viti 1985 filloi te ngrihet dhe Rrjeti i Regjistrimit te Lekundjeve te Forta- rrjeti akselerografik e sizmoskopik, i cili numeronte29 pika vrojtimi te pajisura me akselerograve te tipit SMA-1 me regjistrim analog ne film, dhe me nga nje sizmoskop. Me keto aparatuar u pajisen , sic permendem me lart, stacionet sizmologjike dhe u instrumentuan te gjitha digat e H/C mbi lumin Drin si dhe ato te lumit Mat si dhe disa godina te larta- kryesisht Hotele ne: Tirane, Elbasan, Shkoder, Durres, Elbasan, Berat, Pogradec, Korce dhe Sarande (kryesisht hotele turistike).
Per perpunimin dhe analizen e regjistrimeve te lekundjeve te forta Qendra u pajis ne vitin 1986 me sistemin e analizes te tipit SORD me nje tavoline digitalizuese dhe te gjitha akasesoret e tjere si dhe me softin perkates.
Ne vitin 1986 Qendra u pajis edhe me disa teknika te tjera te kohes te cilatsherbejne per studimet fushore ne sizmologjine inxhinerike dhe ate te inxhinerise se termeteve si me sistemin per matjen e vibrimeve te ambjentit tipi VSS-1 qe sherben per troje ne studimet e mikrozonimit dhe per objektet ne fushen e inxhinerise se termeteve; u pajisem gjithashtu edhe me nje stcion 6 kanalesh tipi OYO per matjenee shpejtesisese se valeve gjatesosre dhe terthore ne siperfaqe dhe ne puse me metoden cross hole dhe down hole.
Sic permendem edhe me lart qe nga shtator te vitit 1968 filloi perpilimi dhe botimi i raporteve javore, mandej dhjete ditore, mujore dhe vjetore ne te cilat permbahen te dhenat e regjistrive te rrjetit sizmologjik te Shqiperise te perpunuara. Buletine e te gjithe llojeve jane botuar e botohen ne dy gjuhe- shqip dhe anglisht. Theksojme se Buletinet Sizmologjike Vjetore, qe filluan te botohen nga viti 1976 permbajne te dhena plotesisht te perpunuara instrumentale dhe makrosizmike te termeteve qe jane regjistruar nga rrjeti i yne. Buletinet vjetore perbeheshin nga tre pjese: pjesa e pare permbante regjistrime dhe perpunime te termeteve te vendit tone dhe rreth nesh, pjesa e dyte te dhena per termetet e larget te regjistruar, ndersa e tretakatalogun

vjetor te termeteve te Shqiperise se bashku me hartat perkatese te izosejsteve dhe harten e epiqendrave. Buletinet vjetore jane botuar vazhdimisht qe permbajne te dhena nga viti 1969.

3. RILEVIMET GRAVIMETRIKE

Rilevimet e para gravimetrike i përkasin atyre të viteve 1931-1942, të kryera nga gjeofizikanët italianë në Kuçovë dhe Selenicë për kërkimin e naftës dhe të serës.

Rilevimet në shkallë të gjerë në Ultësirën Prandariatike, në shkallën 1:100.000 filluan të kryhen nga viti 1950, për kërkimet e naftës e të gazit, të drejtuara nga gjeofizikantja ruse Jurkova L.A. Në vitin 1961, rilevimet gravimetrikë të shkallëve 1:50.000 u drejtuan nga Hasan Topçiu, ndërsa pas mesit të vitit 1963 nga Salo Arapi. Ekipi i gravimetrisë i Ndërmarrjes Sizmo-Gravoimetrike, Fier, nga viti në vit kryen rilevimin në shkallë të mëdha 1: 50.000 dhe 1:25.000 në të gjithë territorin perspektivë për naftë e gaz në zonën Jonike, Kruja, Krastë-Cukali dhe në Ultësirën Prandadriatike (Salo Arapi, Vladimir Veizaj, Themistokli Pulia, Pëllum Karçanaj, Pëllumb Pollozhani, Vojo Dishnica). Gjatë viteve 1963-1967, ky ekip, së bashku edhe me Ligor Lubonjën kryen disa profile rikonjicionalë në Kukës, në korridorin flishor të Okshtunit, si edhe për kërkimin e kromit në masivin ultrabazik të Kukësit. Krahas rilevimeve në shkallën 1:50.000 dhe 1:25.000, ekipi i gravimetrisë i industrisë së naftës përpiloi edhe hartën gravimetrike në shkallën 1:100.000 të zonave perspektive për kërkimin e naftës dhe të gazit, në zonën tektonike Jonike dhe Ultësirën Pranadriatike. Me punën e tyre studimore, ai ekip e renditi gravimetrinë ndër metodat gjeofizike të rëndësishme në kompleksin gjeologo-gjeofizik për kërkimin e naftës dhe të gazit. Me përgjithësimin e vet, Salo Arapi mbrojti me sukses edhe tezën e Kandidatit të Shkencave. Këtë punë kërkimore shkencore e vazhdoi me tej Vladimir Veizaj, veçanërisht në fushën e përpunimit dhe interpretimit të informacionit gjeofizik me kompjuter, i cili gjithshtu përgatiti dhe mbrojti me sukses disertacionin e Kadidatit të Shkencave në vitet nëntëdhjetë, me studimin përgjithësues të shpërndarjes së fushës së forcave të rëndesës në Albanidet.

Përdorimi i gravimetrisë për kërkimin e vendburimeve të mineraleve të ngurta filloi në vitin 1958 me rilevimet për kërkimin e kromit në masivin ultrabazik të Tropojës dhe atë të Bulqizës, të drejtuara nga gravimetristi rus Mihaillovskij J.A. Ai arriti në përfundim negativ mbi mundësinë e përdorimit të gravimetriksë për kërkimin e kromit dhe i ndVrpreu punimet. Në vitin 1959, ekipi i gravimetrisë i Ndërmarrjes Gjeologo-Topografike të Tiranës, nën drejtimin e Mihaillovskijt, kreu me sukses rilevimin gravimetrik në shkallën 1:10.000 në zonën Pobreg-Gjegjan-Morinë, Kukës.

Eksperimentet për kërkimine kromit rifilluan në vitin 1963, nga Ligor Lubonja në rajonin e Kukësit.

Në vitin 1967 u botua artikulli i parë mbi interpretimin e profileve rikonjicionalë gravimetrikë-magnetometrikë në Albanidet, që demonstroi mundësitë dhe aftësitë e këtyrte punimeve për njohjen e Albanideve (Ligor Lubonja, Alfred Frashëri, Anesti Qirinxhi).

Kërkimet gravimetrike muarën një hop cilësor me futjen e metodave mathematikore me anën e kompjuterave për përpunimin dhe interpretimin e të dhënave gravimetrike të matura në terren. Ky hop lidhet me inisiativën dhe punën e një ekipi të përbashkët të Katedrës së Gjeofizikës dhe të Qëndrës së Mathematikës Llogaritëse të Akademisë së Shkencave, duke filluar nga viti 1973, të drejtuar nga Ligor Lubonja, me pjesëmarrjen e Gudar Beqiraj dhe Ylli Veisiu.

Përpjekjet për zbatimin e metodave gjeofizke për kërkimet e vendburimeve të kromit, duke eksperimentuar metodat gravimetrike, magnetometrike dhe atë të polarizimit të provokuar, nga viti 1961 e deri në fillimin e viteve shtatëdhjetë dhe për më tej, muarrën bazën shkencore me disertacionin e Kandidatit të Shkencave, nga Alfred Frasheri, në vitin 1973, ku u analizuan ligjësitë e vetive fizike të kromshpinelideve dhe shkëmbinjve ultrabazikë, si edhe anomalitë gjeofizike të pritshme.

Kërkimet gravimetrike të vendburimeve të mineraleve të ngurtë dhe studimeve krahinore sistematike filluan në Ndërarrjen Gjeofizike të Tiranës me krijimin dhe drejtimin e ekipit të gravimetrisë nga Salvatore Bushati, që nga viti 1973. Për një periudhë mbi 30 vjet, ekipi i gravimetrisë së Qëndrës Gjeofizike të Tiranës, ku bënin pjesë Salvatore Bushati, Pëllumb Karçanaj, Vojo Dishnica, Shpresa Dema u punua në disa drejtime:

- Zgjerimi i fushës së përdorimit të rilevimeve gravimetrike, si edhe të mënyrave të rilevimit sipërfaqësor dhe nëntokësor.
- Kryerja e Rilevimeve sheshore krahinore gravimetrike.
- Ndërtimi i rrjetit mbështetës gravimetrik të Shqipërisë dhe lidhja e tij me atë ndërkombëtar.
- Hartimin e algoritmave dhe kompilimin e programeve standard për përpunimin dhe interpretimin e të dhënave gravimetrike, në bashkëpunim edhe me informaticienët e Institutit të informatikës Gudar Beqiraj etj.

Studimi madhor gravimetrik është Harta e Anomalive Bouguer e Fushës së Gravitacionit e Shqipërisë në shkallën 1:200.000, e cila përbën një kontribut të çmuar edhe në nivel Europian.

Në vitin 1988 Salvatore Bushati paraqiti dhe mbrojti me sukses disertacionin “Studimi krahinor i shpërndarjes së fushës së gravitacionit në Albanidet e Brendshme, në ndihmw të rajonizimit tektonik dhe metalogjenik”.

4. RILEVIMEET MAGNETOMETRIKE

Rilevimet e para magnetometrike janë ato të viteve 1931-1942 të kryera nga gfjeofizikanët Italianë në Kuçovë dhe në Selecinë për kërkimin e naftës dhe të serës.

Në vitin 1957, gjeofizikani gjerman F. Fischer kreu rilevimin magnetometrik në vendburmin e kromit në Kam Tropojë dhe argumentoi karakterin e ndërlikuar të shpërndarkes së fushës magnetike në masivët ultrabazikë dhe tregoi për anomalitë magnetike mbi trupat e kromshpinelideve.

Në vitet 1959-1960, rilevimi magnetometrik u përfshi në kërkimet e vendburimeve të bakrit, me rilevimin ën shkallën 1:10.000 në zonën Rubikut, Kurbnesh-Mashtërkorë dhe Pobreg-Gjegjan-Morinë, të kryera nga magnetometristi rus Boronajev. Në vitin 1960, profile magnetometrikë të detajuar u kryen për kërkimin e linzave të shkrifërimeve që përmbanin magnetit në zonën e Rushkull-Hamallës në veri të Durrësit dhe në Pojan të Fierit (Ligor Lubonja, Alfred Frashëri). Në vitin 1961 u krye rilevimi në shkallën 1:10.000 në rajonin Qafë Bari-Tuç Verior dhe në zonën Derven-Ulzë (Alfred Frasheri, Zoto Rjepaj).

Eksperimentet për rikërkimin magnetometrik të kromiteve rifilluan në vitin 1962 në Vlahnë të Hasit dhe në Tplanë të Tropojës (Ligor Lubonja, Alfred Frashëri)

Punimet magnetometrike, që nga viti 1963 deri në vitet shtatëdhjetë u drejtuan nga Zoto Rjepaj dhe fusha e vepritarisë së tyre ishte kërkimi i kromit në masivin ultrabazik të Kukësit dhe të Bulqizës. U kryen me sukses punime për kërkimin e asbestit në Pukë në mesin e viteve gjashtëdhjetë (Alfred Frashëri, Zoto Rjepaj). Në vitin 1968 u eksperimentua me sukses mikrorilevimi magnetometrik në ndihmë të rilevimit gjeologo-strukturor të masivëve ofiolitike, në Ragam dhe Gzhimë të masivit të Tropojës, etj. (A. Frashëri, Z. Rjepaj). Në vitin 1973 ekipi magnetometrik i Ndërmarrjes Gjeofizike të Tiranës u zgjerua dhe në të u përfshi edhe Petrika Kosho. Gjatë viteve gjashtëdhjetë-tetëdhjetë, ekipi punoi me sukses në disa drejtime:

- Zgjerimi i fushës së përdorimit të rilevimeve magetometrike për kërkimin e vedburimeve të mineraleve të dobishme të ngurta si bakri, kromi, hekur – nikeli, boksidet, asbesti, shkriferimet i mineraleve te rende te rralle e te cmuar, etj.
- Realizimi i progresit në teknologjinë e matjeve, duke kaluar nga magnetometrat prizmatike që matnin komponentet vertikale dhe horizontale të intensitetit të fushës magnetike të Tokës, në përdorimin e magnetometrave protonikë, për matjen e vektorit të plotë T të intensitetit të fushës magnetikë të Tokës.
- Studimi i vetive magnetike të mineraleve dhe shkëmbinjve.

Në vitet tetëdhjetë, magnetometria u përfshi në kryerjen e eksperimenteve të suksesëshme komplekse elektrometrike -

magnetometrike-radiometrike - gjeokimike për kërkimin e drejtpërsëdrejti të shtatimeve të naftës e të gazit në Ballsh (Alfred Frashëri, Petrika Kosho).

Fusha e veprimtarisë së magnetometrisë në vitet nëntëdhjetë u zgjerua dhe e ngrit në një nivel më të lartë, drejtuar nga Salvatore Bushati:

- Kryerja e rilevimeve krahinore në shkallën 1:200.000 në të gjithë territorin shqiptar (Salvatore Bushati). Ky drejtim u kurorëzua më ndërtimin e Hartës Magnetike të Shqipërisë në shkallën 1:200.000. Për realizimin e saj është zhvilluar një veprimtari kërkimore shkencore intensive dhe e gjerë, që prekte si përpunimin e të dhënave fushore, ndarjen e anomalive të rendeve të ndryshme, si edhe interpretative gjeologo-gjeofizike.
- Kryerja e studimeve paleomagnetike në të gjithë territorin shqiptar, sipas projekteve bilaterale Shqipëri-Austri, Shqipëri-Francë, Shqipëri-Greqi (Salvatore Bushati (1992-1995), Alfred Frashëri (1993-1995), Përparim Alikaj (1989).
- Zgjerimi i fushës së përdorimit të magnetometrisë.

5. KERKIMET ELEKTROMETRIKE

Vrojtimet e para elektrometrike janë sondimet elektrike të cekta të kryera me skemën Shlymberzhe, me skema me gjatësi (AB) deri 820 m, për kërkimin e naftës në Kuçovë dhe të bitumit në Selenicë. Këto punime janë kryer nga gjeofizikët italianë të Kompanisë A.I.P.A. me drejtues projektesh A. Belluigi, A. Baglio, and Eng. C. Sq., (A.I.P.A. 1934, Biçoku T. 1964, 2004).

Zbatimi i sondimeve elektrike të thella për kërkimine naftës filloi në vitin 1950, nga ekipi që drejtohej nga gjeofiziku rus Baranov I.A., ku punonin edhe gjeofizikët shqiptarë Teki Biçoku dhe Hasan Topçiu.
Që nga fundi i veteve pesëdhjetë, kërkimet elektrometrike janë zgjeruar shumë, duke u orientuar në disa drejtime:

5.1. Kërkimi i mineraleve të dobishme të ngurta.

Punimet gjeoelektrike për kërkimin e vendburimeve të mineraleve të dobishme të ngurta filluan në vitin 1953, me profilimet elektrike të rezistencës së dukshme për kërkimin e bakrit në zonën e Dervenit, të drejtuara nga gjeofizikantja ruse Maroçkina Z.P., edhe me pjesëmarrjen e gjeologut shqiptar Skënder Dede. Në vitin 1958 kërkimet elektrometrike të bakrit u plotësuan edhe me metodën e potencialit të fushës elektrike natyrore. Në periudhën 1958-1960 vrojtimet me metodën e rezistencës dhe të fushës elektrike natyrore mbuluan disa zona perspektive bakërbartëse në Mirditë e Mat, si në Rubikun Verior-Munazë, Lëkundë, Spaç, Kurbnesh, Lis, si edhe në Gjegjan të Kukësit nën drejtimin e gjeofizikut rus V.M. Pogrebinskiy, ku punuan edhe Ligor Lubonja dhe Alfred Frashëri (Pogrebinskiy,

1959). Poligoni i Gjegjanit u vendos mbi bazën e të dhënave të njoftimeve nga populli në vitin 1959. Mbi bazën e interpretimit të anomalisë së fushës elektrike natyrore dhe të profilimeve elektrike të kombinuara, u projektuan dy puset e parë, një nga të cilët zbuloi vendburimin e madh të bakrit në Gjegjan në vitin 1960. Mbi bazën e interpretimit të anomalive të fushës elektrike natyrore të rilevuara në vitin 1961 nga A. Frashëri, u zbulua vendburimi bakërbartës i Tuçit (fillimisht nga Tuçi lindor).

Tipar karakteristik kërkues kryesor i kësaj periudhe të viteve pesëdhjetë-gjashtëdhjetë ka qënë kërkimi i vendburimeve sulfure të nbakrit të mbuluara nga mbulesa e shfrifët kuaternare. Kësisoj, thellësia e kërkimit ishte vetëm dhjetrat e para të metrave, rrallë më thellë.

Në atë periudhë përdorej edhe metoda e trupit të ngarkuar për të përcaktuar drejtimin e shtrirjes dhe të rënies së trupave xeherorë të kapur nga shpimet ose galeritë e kanalet sipërfaqësorë dhe për të ndihmuar në përshpejtimin e procesit të kërkim-zbulimit, si në Kurbnesh, në Spaç, në Derven etj.

Vitet 1960-1964 ishin edhe periudha e kërkimeve gjeofizike komplekse të shkriférimeve të mineraleve të rëndë e të çmuar, midis të cilavë një vend të rëndësishëm zinin profilimet dhe sondimet elektrike të rezistencës elektrike specifike të dukshme në zonën e litoralit të a Adriatikut nga Lezha në Vlorë dhe në shtratin e shumë lumenjve si Fan, Mat etj. (Ligor Lubona dhe Alfred Frashëri).

Në vitin 1958 u eksperimentua për herë të parë metoda e polarizimit të provokuar duke kryer matje eksperimentale. Kjo metodë në ato vite ishin në fazë ekeperimentale edhe në vendet e përparuara. Këto eksperimente u kryen në Rubik, duke përdorur aparaturën potenciometrike për matjen e diferencave të potenccialeve elektrikë. Meqë kjo aparaturë nuk siguronte saktësinë e kërkuar të matjeve të diferencave kalimtare të potencialeve të polarizimit të provokuar, eksperimentet e vitit 1959 nuk dhanë rezultatet e pritshme. Pogrebinskiy S.A i vazhdoi eksperimentet në zonën e Gjegjanit në vitin 1960, duke përdorur regjistrimin oshilografik të stacionit të elektrometrisë, të porsa erdhur në Shqipëri. Rezultatet ishin pozitive dhe shumë inkurajuese. Këto rezultate krijuan mundësinë që në vitet 1962-1963, Ligor Lubonja dhe Alfred Frashëri të vazhdonin përpunimin e mëtodës së re duke kryer matje për kërkimin e kromit në vendburimin e Kam Tropojës, të Vlahnës dhe në zonën bakërbartëse të Vau Spasit.

Përpjekjet për të përdorur këtë metode të re, që premtonte mundësi zgjidhëse më të mëdha sesa metoda e fushës elektrike natyrore, qëndronin në kërkesën për:

Selektimin e anomalive të potrencialit të fushës elektrike natyrore të cilat kishin natyrë xeherorë nga ato fushës elektrike natyrore që përftoheshin mbi tektonika sterile,
Për të rritur thellësinë e kërkimit dhe

Për të kërkuar edhe zonat e mineralizuara, krahas trupave xeherorë sulfurë të bakrit masiv.

Regjistrimit oshilografik të potencialeve të PP ishte me rendiment shumë të vogël, prandaj metoda përdorej vetëm si detajuese, për vrojtimin në qendrën e anomalive të metodës së fushës elektrike natyrore ose të profilimeve të kombinuara. Mbi bazën e një skeme nga literature, Alfred Frashëri (1963) modifikoi kompensatorin elektronik me gjilpërë për të vrojuar potencialin e polarizimit të provokuar, çka rriti rendimentin në punë, por përsëri metoda nuk doli nga karakteri detalizues. Për të krijuar mundësi të zbatimit të kësaj metode të re, shumë efektive, Ligor Lubonja edhe Alfred Frashëri, në vitin 1965, botuan një ndër të parët libër për PP, jo vetëm në kuadrin e vendit tone: “Metoda e potencialeve të polarizimit të provokuar për kërkimin e xeherorëve dhe studimin e prerjeve të puseve”. Në këtë periudhë vazhdoi përsëri eksperimentimi që argumentoi se metoda e polarizimit të provokuar ishte e aftë të kërkonte kromitet mbi bazën e anomalive që lidhen me praninë e magnetitit dytësor dhe të sulfideve disperse në masën xeherore në vendburimin e Cërrujës (Ligor Lubonja, Alfred Frashëri). Bazën e mundësisë së përdorimit të metodave klomplekse gjeofizike gravimetrike, magnetometrike dhe të polarizimit të provokuar e hodhi i pari disertacion në fushën e gjeofizikës xeherore "Vetitë fizike të kromshpineliteve dhe të shkëmbinjve ultrabazikë të masivit të Tropojës, lidhur me anomalite e pritshme gjeofizike" (Alfred Frashëri, 1974).

Rritja e aftësive rilevuese të elektrometrisë për kërkimin e xeherorëve, ndodhi me krijimin e ndërmarrjes Gjeofizike në vitin 1971. Ekspedita Gjeofizike e Ndrërmarrjes Gjeologji-Gjeodezi e Tiranës, u riorganizua dhe shndërrua në Ndërmarrjen Gjeofizike të Tiranës, për ta ngritur gjeofizikën e kërkimit të mineraleve të dobishme të ngurta në nivelin e kërkesave të kohës. Në atë kohë, përpara gjeofizikës xeherore vihej detyra e kërkimit të trupave xeherorë, si edhe i zonave të mineralizuara në thellësi më të mëdha sesa në vitet gjashtëdhjetë dhe të rritej efektiviteti i rilevimeve elektrometrike në verifikimin e anomalive. Me krijimin e ndërmarrjes gjeofizike dhe me ardhjen e një ekspedite komplekse kineze me aparaturat gjeofizike përkatese, metoda e polarizimit të provokuar mori zhvillim të madh në kërkimin e mineralizimit sulfur të bakrit. Në këtë periudhë, nga viti në vit, Radium Avxhiu dhe Esat Daja dhanë një kontribut shumë të çmuar për tu përgjigjur sa më mirë kërkesave për shtimin e vëllimit të punës me metodën e polarizimit të provokuar dhe për ta kthyer atë në metodë rilevuese.

Me futjen në zbatim të gjerë të kësaj metode të re e të fuqishme për kërkimikn e bakrit, metoda klasike e fushës elektrine natyrore kaloi në plan të dytë, dhe mbeti metodë detalizuese të anomalive. Më këtë, u bë një hop teknologjik i madh përpara, që shpejt dha frytet e veta në kontributin e elektrometrisë për kërkimin e vendburimeve të bakrit. Këto realizime u bënë të mundura edhe më plotësimin e personelit inxhinjer, sepse kjo periudhe përkon edhe diplomimin e kuadrove të brezit të dytë në vitin 1973. pas rihapjes së degës së gjeofizikës në Fakultetin e Gjeologjise dhe te Minierave në vitin 1968.
Krijimi i grupeve komplekse me specialiste elektrometristë, magnetometristë, gravimetristë, gjeologë e gjeokimistë realizoi një përparim të dukshëm të teknologjisë së kërkimeve gjeofizike komplekse, e cila bëri të mundur kërkimin efektiv të mineraleve sulfurë të bakrit në të gjithë brezat produktive të zonës tektonike Mirdita. Niveli i aparaturës në vitet shtatëdhjetë lejonte një thellësi kërkimi me metodat e PP dhe Rezistences në nivelin 100-200m. Ekspedita e bakrit e drejtuar nga Radium Avxhiu, ne perberje te se ciles benin pjese elektrometristet me eksperience Esat Daja, Mihallaq Malaveci dhe brezi i ri, Llesh Prenga, Përparim Alikaj, Spartak Kasapi, Thimi Nathanaili, Astrit Krifca, Idriz Jata, Pëllumb Haxhiu, Ludvig Kapllani, Fatmir Duli, Nustret Kastrati, Nexhip Maska, Ivoni Çani, Sadete Mata, Teuta Rapo, Afërdita Kullaj, Natasha Koco, etj., arriti një efektivitet mjaft të mirë kërkimi, jo vetëm në mineralet e bakrit por edhe të polimetaleve, të mineraleve të çmuar, të boksideve, etj.

Në këtë periudhë, elektrometria ka kontribuar mjaft në zbulimin apo shtimin e rezervave të vendburimeve të bakrit në Qafë Bari, Kaçinar, Palucë, Lak Roshi, Golaj-Nikoliq, Perlat, Karmë-Palaj, Rehovë, etj.

Në vitet shtatëdhjetë, Ligor Lubonja, Alfred Frasheri, Mihallaq Malaveci dhe Thimi Nathanaili kryen kërkime të boksideve me anën e sondimeve të PP dhe të rezistences së dukshme me skemën e Shlumberzhe dhe të gradientit të mesëm, në vendburimet e boksideve në vargun Krujë-Dajt, në Alpe, në rrethin e Librazhdit, etj.

Në vitin 1981, me ardhjen e aparaturave të reja të PP/Rezistences në fushë kohe dhe frekuence nga Kanadaja filloi një periudhë e re e zbatimit të metodave elektrometrike në ndërmarrjen gjeofizike (Përparim Alikaj). Stacioni i fuqishëm elektrometrik, i përbërë nga dhënësi IPC-7/15 kW dhe marrësi shifror IPR-10 u fut në shkallë të gjerë në kërkimin e mineralizimit sulfur të bakrit dhe në problemet e gjeologjisë regjionale në thellësi të mëdha, mbi 700m. Objekte të punës kanë qënë rajonet Gjegjan-Morinë (Kukës), Perlat-Prosek dhe Rubik (Mirditë) dhe Rehovë-Vithkuq (Korçë). Efektiviteti i punimeve me këtë stacion ka qënë mjaft i mirë, me rezultate konkrete në shtimin e rezervave të bakrit në rajonet e Perlatit dhe të Rehovës dhe për vërtetimin e strukturave gjeologjike, në thellësi të mëdha në rajonin e

Gjegjanit. Në vitin 1987 erdhi edhe një stacion i dytë elektrometrik i fuqishëm (GEVI 6 kW) nga Çekosllovakia, i cili u fut gjithashtu në kërkimin e mineralizimit sulfur të bakrit dhe në problemet e gjeologjisë regjionale në thellësi të mëdha (Sami Nenaj).

Në vitin 1978 Përparim Alikaj eksperimentoi, fillimisht në modelime 2D e më vonë në vrojtime eksperimentale në terren, një metodikë të re vrojtimi e paraqitjeje elektrometrike të quajtur "Prerje Reale" e PP/Rezistencës. Thelbi metodës qëndronte në përputhjen sa me të saktë të përhapjes së parametrave gjeoelektrike (PP e rezistencë) me trupat xeherore sulfurë të vërtetuar me shpime e punime nëtokësore. Shpejt metoda tregoi efektivitet të lartë në kërkimin e mineralizimeve sulfure deri në thellësi 700m (Gjegjan, Perlat, Rehovë). Në vitin 1991 metoda u eksperimentua nga P. Alikaj në Kanada, ku zuri një vend të rëndësishëm në kompleksin e metodave gjeofizike të kërkimit të mineraleve sulfure dhe arit. Që nga viti 1995 metoda u përhap me shpejtësi në mbi 30 vende të ndryshme në të gjithë kontinentet. Kontributet më të rëndësishme të "Prerjes Reale" i përkasin vendburimit gjigand polimetalor të San Nicolas në Meksikë, brezave ar-mbajtës pranë Timminsit në Ontarion Veriore, vendburimeve të arit në British Columbia, Yelloëknife, Quebec (Kanada), vendburimeve të arit e bakrit në Kili, Argjentinë, Brazil, Mongoli, etj. Metoda është patentuar nga kompania kanadeze Quantec Geoscience në Kanada.

Në vitin 1985, me ardhjen e aparaturës elektrometrike IPR-11 nga Kanadaja, filloi eksperimentimi i metodës bashkëkohore të PP Spektrale për dikriminimin e tekstures së mineralizimeve sulfure (Pëparim Alikaj, Nehat Likaj). Eksperimentet përfshinë jo vetëm matjet laboratorike por edhe ato në terren. Eksperimentime të ngjashme u kryen në këtë kohë edhe nga Idriz Jata me aparaturën hungareze Diapir.

Krahas mineraleve të sulfureve të bakrit, eksperimente elektrometrike me metodat e rezistencës dhe PP janë vazhduan në vitet shtatëdhjetë nga ndërmarrja gjeofizike edhe në kërkimin e kromit (Llambi Langora, Fatmir Duli, Llesh Prenga etj.). Në vitet 1981-1991 metodat elektrometrike zunë vendin e duhur të përhershëm në kompleksin e metodave gjeofizike në kërkimin e kromit në vendin tonë, megjithëse efektiviteti i gjeofizikës për kërkimin e kromiteve, siç është e mirënjohur, është më i ulët sesa për kërkimin e sulfideve të bakrit.

Në vitin 1972 u krijua ekspedita e ektrometrisë me rrymë alternative, e drejtuar nga Robert Ballta, e cila përfshinte metodën elektromagnetike të këndit të inklinimit (Piro Leka), metodën e radiovaleve (Elsa Malo, Kristaq Naska, Dhimitër Gjovreku, Fatmira Gjocaj, etj.), e me vonë metodën EM të TURAM-TURAM (1981) (Dhimitër Gjovreku). Detyra e kësaj ekspedite ka qënë kërkimi i mineralizimeve sulfure masive në sipërfaqe e mjediset nëntokësore

(galeri e shpime). Kësaj ekspedite iu bashkangjit në vitin 1978 edhe metoda e magnetometrisë vektoriale nëntokësore, e cila u përdor për kërkimin e trupave qorrë të bakrit e kromit, të shoqëruar me minerale magnetike. Efektiviteti i metodave të radiovaleve dhe magnetometrisë vektoriale ka qënë mjaft i mirë, duke kontribuar në shtimin e rezervave të mineraleve të bakrit e kromit në shumë miniera të vendit tonë.

Rezultatet shumë të mira të kërkimeve elektrometrike të vendburimeve të bakrit shërbyen si materiali kryesor bazë të hartimin e disertacioneve të kandidadit dhe të doktorit të shkencave nga disa specialistë gjeofixikë të Ndërmarjes Gjeofizike të Tiranës, duke filluar me Radium Avxhiun (1979 kandidat i shkencave dhe 1990 doktor i shkencave), Nehat Likaj, Përparim Alikaj (1989), Dhimitër Gjovreku dhe Piro Leka. Këto disertacione shërbyen më së miri për përparimin e mëtejshëm dhe rritjen e efektivitetit të kërkimeve elektrometrike të mineraleve të dobishme të ngurta, në rradhë të parë të sulfureve të bakrit.

Vitet tetëdhjetë ishte periudha e studimeve intensive dhe e eksperimenteve për rritjen e thellësisë së kërkimeve gjeofizike deri në 800-1000m, duke hapur rrugën e përdorimit të vrojtimeve gjeoelektrike nëntokësore në shpime (Ligor Lubonja, Alfred Frashëri, Radium Avxhiu, Përparim Alikaj, Neki Frashëri, 1984-1987).

Përparime me spektër të gjerë u arritën bazuar në përpunimin dhe interpretimin të informacionit elektrometrik me anën e kompjuterit. Në vitin 1974, me nismën e Ligor Lubonjës, filloi hartimi i programeve të para për përpunimin dhe interpretimin e të dhënave të vrojtimeve elektrometrike (Alfred Frashëri, Gudar Beqiraj, Neki Frashëri, Ylli Vejsiu, Dhimitër Tole, Radium Avxhiu, Nehat Likaj, Ivoni Çani, më pas edhe Fatbardha Vinçani). U hartuan algoritmat dhe u kompiluan 70 programe standard për përpunimin dhe interpretimin e të dhënave elektrometrike. Në vitet nëntëdhjetë u realizua paketa e programeve për modelimet mathematikore dhe inversionit të informacionit të polarizimit të provokuar (Alfred Frashëri, Neki Frashëri).

Vlen të përmëndet këtu krijimi i një bërthame të fuqishme elektronistësh, të drejtuar nga Engjëll Çiraku dhe të përbërë nga Xhaferr Hakani, Hajri Shehu, Shpëtim Najdeni, Qirjako Qirjaqi, e Bashkim Besho, të cilët jo vetëm kanë përballuar riparimin e shpejtë dhe cilësor të aparaturave gjeofizike, por shpesh kanë bërë edhe modifikime me vlere apo edhe kanë prodhuar aparatura të reja.

5.2. Në kërkimin e naftës dhe të gazit

Pas sondimeve elektrike vertikale të cekta gjatë viteve tridhjetë dhe sondimeve të thella në fillimin e viteve pesëdhjetë, në vitin 1978 rifilloi kryerja e sondimeve elektrike të thella në kërkimin e naftës e të gazit (Alfred Frashëri, Lefter Jani, Kozma Ciruna). Nga viti 1978 deri ne

fillimin e viteve nëntëdhjetë u kryen sondime elektrike të thella, me $(AB)_{max}$=12 km, më thellësi studimi rreth 2.5 km dhe thellësi ndikimi deri 4500m, si pjesë e kompleksit gjeologo-gjeofizik për kërkimin e naftës dhe të gazit, në tre drejtime:

- Per te identifikuar tavanin e strukturave gelqerore, në rajonin e Vurgut, të Vlorës dhe Kuçovës.
- Për të vlerësuar ranoritetin e prerjeve neogjenike në shelfin Shqiptar të Adriatikut dhe në Vlorë.
- Për të trasuar kontaktin e diapirit të Dumresë në thellësi.

Në vitet 1978-1982 u eksperimentua me sukses në vendburimet e naftës e gazit në Ballsh-Cakran, rilevimi i fushës elektrike natyrore, si pjese e kompleksit gjeofizik-gjeokimik elektrometri-magnetoimetri-radiometri dhe rilevim gazor për kërkimin direkt të shtratimeve të naftës dhe të gazit (Frashëri A., Krifsa A., Kosho P).

5.3. Elektrometria detare për studimin e shelfit shqiptar të Adriatikut.

Viti 1975 hapi një epokë të re për zbatimin e metodës së rezistencës duke kryer ciklin e parë të profilimeve elektrike detare në shelfin Shqiptar të Adriatikut, të kryera nga Alfred Frashëri, Radium Avxhiu, Përparim Alikaj, Spartak Kasapi. Bazuar mbi këto eksperimente, në fundin e viteve shtatëdhjetë u ngrit ekspedita detare elektrometrike (Alfred Frashëri, Vasillaq Leci). Në vitin 1982 u kryen sondimi i parë elektrik detar me skemën Schlumberger me gjatësi deri AB/2= 8 km, në det me thellësi uji deri 50 m. Matjet u kryen me anën e stacionit të elektrometrisë detare i projektuar dhe ndërtuar me fuqi 250 kW nga Alfred Frashëri, Reis Çani, Ymer Luga, Franci Malo dhe Burhan Çanga. Vrotimet elektrometrike detare u kryen sistematikisht, nga Gjiu i Vlorës deri Gjiun e Drinit, me anën e sondimeve elektrike të thella, me $(AB)_{max}$=16 km dhe me profilime me skema të ekranizuara dhe diferneciale, për studimin e shelfit detar te Adriatikut, duke arritur thellësi studimi deri 2500 m dhe thellësi ndikimi deri 3500m (1984-1989) (Alfred Frasheri, Vasillaq Leci, Kozma Ciruna), duke dhënë kontributin e vet edhe në zbulimin e shtatimit të gazit në det në strukturën e Durrësit.

5.4. Elektrometria inxhinjerike dhe e mjedisit

Punimet e para të gjeofizikës inxhinjerike janë sondimet elektrike të kryera në sheshin ku u ndërtua uzina e plehrave azotike në Fier (Zoto Rjepaj), sondimet dhe profilimet elektrike per studimin e bregdetit dhe të shtrateve të lumenjve (Ligor Lubonja, Alfred Frashëri) në fillimin e viteve gjashtëdhjetë. Pas tyre vijnë sondimet elektrike dhe profilet sizmike në aksin e digës së hidrocentralit në Vaun e Dejës në fillimin e viteve shtatëdhjetë (Sillo Muçko), trasenë e hekurudhës Milot-

Burrel dhe superstradës Fushë Krujë – Milot (Ludvig Kapllani). Në gjysmën e parë të viteve tetëdhjetë u kryen sondime dhe profilime elektrike, në kuadrin e studimeve komplekse gjeologo-gjeofiziko inxhinjerike, krahas edhe rilevimeve gravimetrike, sizmike etj. për rindërtimin e rezervuarëvë në zonat karstike në shumë rrethe të vendit, në të cilët filtornte uji nga zonat karstike në kupat e tyre (1981-1985) (Alfred Frashëri, Ludvig Kapllani, Salvator Bushati).

Sondimet elektrike vertikale të rezistencës elektrike specifike të dukshme shoqëruan në vitet tetëdhjetë edhe mikrozonimin sizmologjik të qyteteve kryesorë të Shqipërisë, në kompleks edhe me vrrojtimet sizmike inxhinjerike të frekuencës së lartë (Siasi Koçiu, Ludvig Kapllani).

Dhjetëvjeçari i fundit është edhe periudha kur gjeofizika inxhinjerike po njeh zhvillimin më të madh edhe në Shqipëri. Ekipet e Gjeofizikës së Shërbimit Gjeologjik Shqiptar, të Institutit të Sizmologjisë, të Fakultetit të Gjeologjisë dhe të Minierave, OJQ si edhe ekipe private, po zhvillojnë me sukses degën e gjeofizikës inxhinjerike dhe të mjedisit. Midis komplesit gjeofizik, rezistenca elektrike specifike është një nga parametrat kryesorë të kontrolleve:

Në vitet nëntëdhjetë, Seksioni i Gjeofizikës së Fakultetit të Gjeologjisë dhe të Minierave në Universitetin Politeknik të Tiranës, përpunuan metodat e tomografisë sizmike dhe të elektrometrisë inxhinjerike sipas rezistencës elektrike specifike të dukshme për studimin i edhe kontrollin in-situ të gjendjes teknike të digave, të vlerësimit të qëndrueshmërisë së shpateve dhe studimin e rrëshqitjeve, si edhe kontrollin e ndërtimeve të ndryshme (Alfred Frashëri, Pertef Nishani, Ludvig Kapllani, Burhan Çanga). Kontribut i rëndësishëm i vrojtimeve sizmike më frekuencë të lartë dhe i sondimeve elektrike është dhënë edhe për përpilimin e Hartës Gjeolog-Inxhinjerike të Shqipërisë në Shkallës 1;200.000 gjatë viteve nëntëdhjetë (Pertef Nishani Ludvig kapllani, Burhan Çanga).

Vazhdon studimi i rrëshqitjeve dhe vlerësimi i stabilitetit të shpateve me anën e sondimeve elektrike (Piro Leka), studimi i lumenjve dhe i bregdetit në stere (Idriz Jata, Piro Leka, Vladimir Kavaja, etj).

Midis këtyre punimeve përmëndim hapjen e fushave të reja të gjeofizikës inxhinjerike dhe mjedisore, siç është studimi i vend-depozitimeve të mbeturinave te rrezikshme (2005) (Përparim Alikaj).

Fusha e zbatimeve të gjeofizikës është zgjeruar edhe për studimin e problemeve të impaktit mjedisor në gjeomjedis dhe në sistemet ujore të Shqipërisë, siç janë ato në bregdetin e Adriatikut dhe në liqenin e Prespës, të Ohrit e të Shkodrës, të ndryshimeve të klimës sipas të dhënave gjeotermale (2000-2005) (Alfred Frashëri).

5.5. Elektrometria në hidrogjeologji

Sondimet elektrike dhe karotazhi elektrik janë përdorur gjerësisht edhe në kërkimet e ujit, nga Pëllumb Haxhiaj, Nexhip Maskaj and Genc Kallfa, në fillimet e viteve tetëdhjetë. Aktualisht, me këto metoda po punojnë për Përparim Alikaj, Radium Avxhiu, Llesh Lleshi, Idriz Jata, Piro Leka, kërkimet hidrogjeologjike në basenet e tipeve ujëmbajtës të ndryshëm, përfshirë edhe ujërat termalë Mamurras, dhe në Llixha të Elbasanit. Në zbatim të projektit bilateral shqiptaro-grek u zbatua tomografia elektrike e rezistencës së dukshme, në komplkes me magnetometri dhe VLF në burimet e ujVrave termalë në Sarandopouros (Salvatore Bushati, Sami Nenaj, Hamza Reçi, Genc Hoti) në vitet 2004-2005.

5.6. Elektrometria në kërkimet arkeologjike

Profilimet dhe sondimet elektrike të para për kërkimet arkeologjike janë kryer ne qendrën antike të Margëlliçit në fillimin e viteve shtatëdhjetë (Alfred Frashëri, Radium Avxhiu). Në periudhën e fundit njëzetvjeçare, këto punime i ka vazhduar me sukses të madh Vladimir Kavaja, Igli Nakuçi, Fatbardha Vinçni, në qendrat e mëdha arkeologjike të Apolonisë dhe të Butrintit. Në zbatim të projektit bilateral shqiptaro-grek uzbatua tomografia elektrike në kompleks me magnetometrike në trasenë e Via Egnatia (Salvatore Bushati, Sami Nenaj, Hamza Reçi, Genc Hoti dhe arkeolog Ilir Gjipali) në vitet 2004-2005.

5.7. Elektrometria në hartografimet gjeologjike dhe në studimet gjeologjikekrahinore.

Profilimet elektrike, si edhe sondimet elektrike të rezistencës së dukshme më skema të gjata dhe thellësi studimi nga 1000-3000 m janë kryer në disa rajone të vendit, me probleme gjeologjike:

- Rilevimet në shkallën 1:10.000 me profilime elektrike simetrike nw rajonet Pobreg Morine (1960-1961) (S.A. Pogrebinksiy S. dhe Alfred Frasheri)
- Rilevimet në shkallën 1:10.000 me profilime elektrike simetrike nw rajonet Qafw Bari-Tuçi verior (1961) (Alfred Frasheri)

Në gropën neogjenikë të Korçës, krahas edhe vrojtimeve sizmike (1962) (Alfred Frasheri).

Në gropën neogjenikë të Burrelit krahas edhe vrojtimeve sizmike në gjysmën e dytë të viteve tetëdhjetë (Lefter Jani).

Në Gjegjan të Kukësit në gjysmën e dytë të viteve tetëdhjetë (Përparim Alikaj).

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Në përfundim të kësaj analize për zbatimet e metodave elektrometrike konstatohet:

1. Vrojtimet elektrometrike janë përdorur me sukses të madh kryesisht për kërkimin e vendburimeve të mineraleve të dobishme të ngurta, në rradhë të parë të mineraleve të bakrit, dhe kanë qënë metoda bazë të kompleksin kërkues gjeofizik.

2. Për kërkimin e bakrit janë përdorur me sukses të gjitha metodat e kohës për elektrometrinë e rrymave të vazhduara dhe disa nga ato të rrymave alternative, si metodat: e polarizimit të provokuar, të fushës elektrike natyrore, të profilimeve dhe sondimeve elektrike të rezistencës së dukshme, të trupit të ngarkuar, të elektro korrelacionit, të profilimeve induktive me rezistencë të ulët dhe TURAM-TURAM, të VLF dhe të radiovalëve.

3. Kërkimi i vendburimit të bakrit në periudhën 1953-1990 kaloi në tre faza:
Në vitet gjashtëdhjetë elektrometria zgjidhte kryesisht detyrën e kërkimit të trupave sulfurë të bakrit nën mbulesën e shkrifët kuaternare, me thellësi kërkimi dhjetra metra. Metoda kryesore rilevuese ishte ajo e potencialit të fushës elektrike natyore dhe e profilimeve të kombinuara të rezistencës së dukshme. Elektrometria kontribuoj në zbulimin e vendburimit të Gjegjanit, të Tuçit, dhe në zgjerimin e vendburimit të Dervenit, etj.

Në vitet shtatëdhjetë-tetëdhjetë u kërkuan vendburimet e sulfureve të bakrit të trupave me teksturë massive dhe me mineralizim të shpërndarë në thellësi qindrat e para të metrave. Metoda kryesore rilevuese u bë ajo e polarizimit të provokuar. Kontributi i elektrometrisë në këtë periudhë ishte shumë më i lartë, duke drejtuar zbulimin e vendburimeve Qafë Bari, Kaçinar, Palucë, Lak Roshi, Golaj-Nikoliq, Perlat, Karmë-Palaj, Rehovë, etj.

Në gjysmën e periudhës të dytë të viteve tetëdhjetë u rrit thellësia e kërkimit deri 700-800 m, nëpërmjet përdorimit të stacioneve elektrometrike të fuqisë së madhe, kombinuar me metodikat e përparuara të vrojtimit, nëpërmjet vrojtimeve me thellësi të ndryshme kërkimi midis të cilave të prerjes reale, si edhe të vrojtimeve nëntokësore në shpime e galeri.

4. Gjatë periudhës 1950-1990, sondime elektrike të rezistencës së dukshme janë përdorur në vëllim të vogël për kërkimet e naftës dhe të gazit në stere dhe në shelfin detar të Adriatikut, për kërkimin e shkrifërimeve të mineraleve të rëndë, të rrallë dhe të çmuar për zgjidhjen e detyrave inxhinjerike, të boksideve në ndihmë të hartografimit gjeologjik dhe të studimeve krahinore, të kërkimeve hidrogjeologjike dhe atyre arkeologjike.

5. Pesëmbëdhjetë vjetët e fundit, studimet dhe kërkimet elektrometrike me metodat konvencionale të rrymës së vazhduar, kryesisht me metodën e profilimeve dhe të sondimeve elektrike po orientohen gjithënjë e më shumë për zgjidhjen e detyrave të gjeologjisë inxhinjerike, të kërkimeve hidrogjeologjike dhe të gjeoteknikës, si edhe mjedisore.

6. Pas vitit 1991, Ndërmarrja Gjeofizike e Tiranës ka pësuar ndryshime rrënjësore, duke u shkurtuar mbi 20 herë në personel dhe duke e orientuar zbatimin vëllimeve të vogla të profilimeve dhe sondimeve elektrike të rezistencës kryesisht në problemet e gjeologjisë mjedisore, hidrogjeologjisë, burimeve gjeotermale, gjeologjise inxhinjerike dhe arkeologjisë (Radium Avxhiu, Llesh Prenga, Sami Nenaj, Piro Leka, Idriz Jata, Vladimir Kavaja, Spartak Kasapi, Hamza Reci, etj.).

6. KËRKIMET DHE STUDIMET RADIOMETRIKE NË SHQIPËRI.

Matjet e para radioaktivitetit natyror të mineraleve të dobishme në Shqipëri, si përshembull, të hekur-nikelit, të serës, etj., janë kryer në vitin 1958-1959, nga gjeologë rusë dhe çekë, të cilët punonin në atë kohë në Shqipëri. Por kërkimet e organizuara mirë dhe të proramuara për kërkimin e mineraleve të dobishme radioaktive, në rradhë të parë të uranit në Shqipëri, filluar në vitin 1960 në shumë rajonë të Shqipërisë. Këto kërkime përbënin gama rilevime në terren, matje radiometrike në galeritë e kërkimit në Shqipëri dhe përcaktime radioaktive laboratorike të alfa, beta dhe gama rrezatimeve. Këto punime ishin plotësisht të mbyllura, tepër sekrete. Nga pala shqiptare, në atë periudhë, në ekipet radiometrike merrnin pjesë edhe inxhinjer gjeologët Niko Shkodrani, Vangjel Liko dhe inxhinjer Anastas Dodona. Në vitin 1963, këtij ekipi u bashkangjit edhe inxhineri gjeofizik Lambi Langora, i cili në vitet shtatëdhjetë-tetëdhjetë i drejtoi këto kërkime, dhe më pas edhe gjeologu Vasil Nasi, si edhe fizikantja Valdete Sala për përcaktimet laboratoratorike. Në ato vite, në laorator bëheshin përcaktime integrale të gama rrezatimit dhe beta + gama rrezatimeve ë uranit ekuivalent dhe radiumit. Nga viti 1978 filloi eksperimentimi i analizava gama spektrometrike sips elementëve radioaktivë U, Ra, Th, K (Anastas Dodona dhe Petrit Skënde nga Instituti i Fizikës Bërthamore), por vëtëm nga viti 1986 filloi që gama spektrometria të zbatohej për studimet gjeokimike për studimin e elementëve gjurmë dhe për kërkimin e mineraleve radioaktivë dhe joradioaktivë, Në vitet shtatëdhjetë-tëtëdhjetë, ekipet radiometrike u zgjeruan edhe me specialistë të tjerë të rinj, Safet Dogjani, Pëllumb Kasapi, Riza Bega, Petrit Kodheli, Osman Lika, Merita Dalipi, etj. Gjatë përiudhës së viteve shtatëdhjetë u kryen shumë punime gjeologo-minerare dhe radiometrike në objekte si Nimçe në rajonin e Kukësit, etj. të cilat nuk u kurorëzuan me zbulimin e vendburimeve industriale të uranit, dhe

me kalimin e viteve u mbyllën. Një përgjithësim dhe klasifikim të anomalive radiometrike bëri në atë kohë Llambi Langora në disertacionin tij.

Realizimi i aktivimit neutronik, nga Instituti i Fizikës Bërthamore në bashkëpunim me Ekspeditën Radiometrike në vitet tetëdhjetë, krijoi mundësinë e kryerjes së analizave ekspres, sipas teknologjive moderne për shumë elementë, dhe në Shqipëri.

Vitet nëntëdhjetë sollën hapjen e kërkimeve radiometrike dhe orientimin e tyre për zgjidhjen e shumë problemeve të rëndësishme, të cilat nuk kishin lidhje më kërkimin e vendburimeve të uranit. Në këtë periudhë, drejtimet e kërkimeve dhe studimeve radiometrike qëndronin në:

Së pari, në progresin e studimeve radiometrike duke zbatuar përcaktimet laboratorike gama spektrometrike sipas elementëve radioaktivë U, Th, K në mostra gjeologjike, në kuadrin e rilevimeve gjeokimike krahinore në Shqipëri për hartimin e Atlasit Gjeokimik të Shqipërisë. Këto punime u drejtuan nga Anastas Dodona, me pjesëmarrjen edhe të Merita Dalipi, në bashkëpunim të ngushtë shkencor edhe me spesialistë të Institutit Bërthamor të Akademisë së Shkencave. Rezultatet e këtyre përcaktimeve radiometrike spektrale u përfshinë në Atlasin Gjeokimik të Shqipërisë, duke dhënë një kontribut që i kapërxen kufinjtë e vendit. Në veçanti u vlerësua radioaktiviteti i argjilave të Shqipërisë, si edhe dominantet e raporteve të radioizotopëve natyrorë, si tregues të përqëndrimeve të elementëve të rrallë, të çmuar dhe të polimetaleve.

Së dyti, në studime radiometrike krahinore madhor sipas parametrit të gama rrezatimit total, siç është "Studimi i radioaktivitetit natyror të Shqipërisë" (Safet Dogjani, Osman Lika, Llambi Langora (1997), që për nga rëndësia i kalon kufinjtë e vendit. U realizua edhe studimi i rëndësishëm me karakter mjedisor "Studimi i efektit radiologjik të shkaktuar nga punimet e zbulimit të uraniumit në Shqipëri" (Llambi Langora. Osman Lika. Safet Dogjani) (2001).

Së treti, është drejtimi shumë i rëndësishëm mjedisor mbi studimin dhe monitorimin e përqëndrimit të Radonit në mbulesat kuaternare të zonës Pranadriatike, në mjediset e brëndëshme dhe në ujin e pijshëm në qytete të ndryshme në Shqipëri, të cilat drejtohen nga Llambi Langora, së toku me Osman Lika dhe Safet Dogjani (1995-2003).

Së katërti, në fillimet e viteve nëntëdhjetë u kryen rilevime komplekse gjeologo-radiometrike në disa rajone të vendit, midis të cilëve edhe për kërkimin e qymyreve uranmbajtëse të Suitës Priska në zonën e Fushë Krujës (M. Saraçi, Petrit Kodheli, Pëllumb Kasapi, Riza Bega dhe Safet Dogjani (1990-1993).

Aktualisht, studimet radiometrike janë orientuar për zgjidhjen e problemeve mjedisore. Krahas kësaj, ka vend edhe të studiohen materialet e ndërtimit që përdoren në Shqipëri, veçanërisht në

prodhimin e tullave dhe tjegullave, të çimentos, të hekurit që përdoret për ndërtim etj. Është e domosdoshme që përcaktimet radiometrike të shtrihen edhe në produktet ushqimore. Përcaktimet kimike me anën e aktivimit neutronik janë një fushë tjetër shumë e rendësishme, që duhet lëvruar. Rilevimet dhe përcatimet gama spektrometrike, si teknologji moderne duhet të jenë në qendrën e vëmëndjes.

7. STUDIMET GJEOTERMALE

Studimet gjeotermale të kryera në kuadrin e realizimit të projekteve “Atlasi Gjeotermal i Albanideve” [1995] dhe “Atlas of the Geothermal Resources in Albania” [1996], janë paraprirë nga matje të temperatures në puse të thellë të naftës dhe të gazit, të kryera qysh nga viti 1951, nga operatorët e parë të karotazhit, si: Hamdi Bejtja, Alfred Frashëri, Agim Luari, Pertef Nishani, Kadri Zalla etj., të Ekipit të Karotazhit të Ndërmarjes së Shpimit në Patos dhe më pas nga operatorët Fatmir Luari, Zylal Mahmutaj etj., të Ndërmarrjes së Gjeofizikës Kantierale të Patosit. Nga këto institucione, temperatura është regjistruar me termometra elektrikë në qindra puse të thellë nafte dhe gazi për të përcaktuar nivelin e ngritjes së unazës së çimentos pas kolonës dhe për të zgjedhur detyra të tjera të ndryshme të karakterit teknik. Në 85 puse është regjistruar temperatura për përcaktimin e gradientit gjeotermal. Gjatë viteve, specialistë të ndryshëm të Ndërmarrjes së Gjeofizikës Kantierale të Patosit, Vladimir Dodbiba, Fejzi Kafexhiu, Daver Çano etj., kanë studiuar dhe përgjithësuar regjistrimet e kryera të temperaturës.

Në disa puse në vendburime të naftës dhe të gazit është matur temperatura edhe me termometra maksimale në disa thellësi, nga specialistë të ndërmarrjeve të nxjerrjes së naftës dhe të gazit dhe të Institutit Teknologjik të Naftës dhe Gazit në Patos.

Në vitin 1990, u krye studimi "Gjeotermia e Albanideve" [A.Frashëri], i cili u përfshi në Atlasin Gjeotermal të Europës, 1992, i botuar nga Geographisch-Kartographische Anstalt Gotha në Gjermani. Hartat gjeotermale të Shqipërisë në këtë Atlas janë dhënë në shkallën 1:2 500 000 dhe janë ndërtuar sipas analizës së 38 termogramave.

Në gjashtëmujorin e dytë të vitit 1992, filloi realizimi i Projektit "Gjeotermia e Albanideve", fryt i të cilit është Atlasi Gjeotermal i Shqipërisë (1995) me të dy pjesët e tij, atë tërësor për Shqipërinë, me harta në shkallën 1: 1 000 000 dhe tjetrin për zonën tektonike Jonike dhe Ultësirën Pranadriatike ku ndodhen vendburimet e naftës dhe të gazit [1993] me harta në shkallën 1: 1 500 000 (Alfred Frashëri, Rushan Liço, Nazif Kapedani etj. dhe shkencëtarë çekë Vladimit □ermak, Jan Šafanda etj).

Atlasi është hartuar duke patur në dispozicion termogramat e:

1) 84 puseve të regjistruara nga ekipet e Ndërmarrjes Gjeofizike Kantierale të Patosit, për periudhën 1952-1993.

2) 59 puseve të regjistruara nga ekipi i Seksionit të Gjeofizikës të Fakultetit të Gjeologjisë dhe të Minierave, vetë ose së bashku me shkencetarët çekë në periudhën 1993-1995.

Vetitë termike të shkëmbinjve, sipas kampioneve të mbledhura në vitet 1993-1995 në Shqipëri, janë përcaktuar nga ekipi shqiptar në Laboratorin e Institutit Gjeofizik të Pragës dhe disa në Departamentin e Gjeologjisë dhe të Gjeofizikës në Universitetin e Barit.

Matjet në miniera, si në atë të Bulqizës janë kryer nga Doc. Hajredin Shtino.

Studimi "Atlas of Geothermal Resources of Albania" u hartua gjatë viteve 1994-1996 nga i njëjti ekip i përbashkët shqiptaro-çek në kuadrin e "Atlas of Geothermal Resources in Europe", i cili u botua në vitin 2002 (Alfred Frashëri, Muhamet Doracaj, Rushan Liço, etj. dhe shkencëtarë çekë Vladimit □ermak, Jan Šafanda etj).

Platforma mbi parimet e përdorimit kompleks dhe kaskadë të energjisë gjeotermale të entalpisë së ulët në Shqipëri, e përgatitur nga Alfred Frashëri gjeti vlerësim nga Workshopi 26-të mbi Inxhinjerinë e Rezervuarëve Gjeotermalë, 29-31 janar 2001, Universiteti Stanford California, USA dhe u botua në materialet e tij.

Vrojtimet, studimet dhe analizat e burimeve dhe të puseve të ujërave termale janë kryer nga shërbimet hidrogjeologjike e gjeofizike të Shërbimit Gjeologjik Shqiptar dhe të Qendrës Kombëtare Shkencore të Kërkimeve të Hidrokarbureve (Avgustinskij V.L. etj., 1957, Radium Avxhiu, etj. 1999, Haki Dakoli, etj. 1981, 2000, Kristaq Dhima, etj. 2000, Harta Hidrogjeologjike e Shqipërisë në shkallë 1: 200 000 , 1985, Romeo Eftimi, etj., 1989, Hamza Reçi, etj., 2001, Mane Tartari, etj., 1999, Telo Velaj, 1995, Salvatore Bushati, etj 2004, Piro Leka, etj 2005).

Në vitin 2003, nga një ekip i gjerë i Shoqatës së Ruajtjes dhe Mbrojtjes së Ujërave Bregdetare dhe të Ëmbla të Shqipërisë (Alfred Frashëri, Niko Pano, Salvatore Bushati, Neki Frashëri etj), u realizua Projekti sensibilizues "Përdorimi i energjisë gjeoteormale miqësore me mjedisin në Shqipëri", UNDP-GEF, SGP. Ky Projekt u realizua së bashku me Institutin e Informatikës dhe të Matematikës së Aplikuar (INIMA). Në kuadrin e këtij projekti u botua një broshurë dhe u përgatit një videokasetë mbi energjinë gjeotermale të Shqipërisë, tre projekte ide mbi përdorimin e nxehtësisë së Tokës për ngrohjen e banesave dhe të serave, mbi përdorimin komplkes dhe kaskadë të energjisë së ujërave termale [Alfred Frashëri etj., 2003], si edhe u organizuan katër workshope sensibilizuese. Broshura është përfshirë edhe në një faqe të internetit të INIMA, si bashkautore e projektit, me adresë:
http://www.inima.al/~nfra/geothermal

Me kërkesën e Institucionit Gjerman Geothermische-Vereinigung, kjo broshurë është futur edhe në faqen e tyre të Internetit: EGEC's GEOTHERNET:
http://www.Geothermie.de

Në kuadrin e këtij projekti u përgatit edhe drafti shqiptar i "Ligji i Energjisë Gjeotermale" [Ermal Frashëri, 2003].

Në vitet 2003-2004, në kuadrin e Programit Kombëtar për Kërkim dhe Zhvillim të drejtuar nga Akademia e Shkencave, u bë e mundëshme të botohet "ATLASI I BURIMEVE GJEOTERMALE NË SHQIPËRI", i cili është përgjithësim i të gjitha studimeve gjeotermale të kryera deri në 2004 në Shqipëri. Atlasi është vendsur në Internet, me URL:
http://www.inima.al/~nfra/projects/geothermal/
GEOTHERMAL ENERGY IN ALBANIA
ATLAS OF GEOTHERMAL RESOURCES IN ALBANIA
Published by Faculty of Geology and Mining,
Polytechnic University of Tirana
Prof. Dr. Alfred Frashëri, Dr. Vladimir Çermak (Co-Editors in chiefs)

8. GJEOFIZIKA E PUSEVE

Metodat gjeofizike për studimin e puseve të naftës janë përdorur për herë të parë në Shqipëri nga gjeofizikët italianë të shoqërisë AIPA, në vitin 1934 në vendburimin e Kuçovës. Ata përdorën karotazhin elektrik të rezistencës elektrike specifike të dukshme, me regjistrim pikësor.

Në mënyrë sistematike, studimi gjeofizik i puseve të naftës filloi në vitin 1950, kur u ngrit grupi i parë i karotazhit në Patos, në kuadrin e Kombinatit të Naftës. Në këtë grup punonte operatori rus David A. Bronshtein, si edhe u përgatitën dy teknikët e parë shqiptarë, Hamdi Bejtja (1951) dhe Alfred Frashëri (1953). Me zhvillimin e mëtejshëm të këtyre metodave, në vitin 1954 u krijua Baza e Karotazhit, me qendër në Patos, që pas vitit 1956 u drejtua nga Inxh. Agim Luari.

Duke filluar me regjistrimin e pandërprerë automatik të rezistencës së dukshme dhe të potencialit të polarizimit spontan, pas punimeve eksperimentale filloi të kryej matja e kompleksit të plotë të sondimeve elektrike anësore të karrotazhit, që lejoi të studiohej prerja gjeologjike e pusit me anën e metodave të elektrometrisë së puseve. Detyrat e zgjidhura në fillim ishin modeste dhe qëndronin në përcaktimin e thellësisë dhe të trashësisë së shtresave, si edhe në ndarjen cilësore të prerjes së shpuar në shkëmbinj me veti të mira dhe në shkëmbinj më përshkueshmëri të keqe.

Në periudhën e viteve pesëdhjetë filloi edhe studimi i gjendjes teknike të trungut të pusit, duke përcaktuar shtrëmbërimin e tij me inklinometra elektrikë, diametrin faktik të trungut të pusit, u regjistrua temperatura në pus me termometra elektrikë dhe u vlerësua gradienti gjeotermal, u përcaktua rezistenca elektrike specifike e solucionit të argjilës dhe i ujërave, si edhe vendi i rrjedhjes së ujërave në pus. Në vitin 1951 filloi hapja e shtresave të naftës me perforim, duke përdorur perforatirë autromatikë me plumba dhe në vitet 1952-1955 u kryen me sukses edhe torpedimet e para në puse. Për hapjen e shtresave të naftës dhe gazit u kalua në përdorimin e perforatorë modernë kumulativë dhe në vitin 1955 filloi marrja anësore e kampioneve. Për herë të parë në praktikën e gjeofizikës kantierale u krye me sukses torpedimi i puseve me torpeda me veprim kumulativ për zhbllokimin e instrumentave të bllokuar të shpimit, po kështu u përdorën torpeda kumulative për shkatërrimin e sendeve metalike të rëna në pus.

Karakteristika e rëndësishme e kësaj periudhe ishte edhe automatizimi i regjistrimeve i të dhënave gjeofizike me anën e stacioneve automatikë të karotazhit, i cili u vu në përdorim për herë të parë në vitin 1955, duke siguruar rritjen e saktësinë së punimeve gjeofizike dhe rendimentit në punë në pus.

Gjatë kësaj periudhe u kompletua kompleksi i studimit të puseve edhe me metoda të tjera. Filloi eksperimentimi i karotazhit gazor dhe atij radioaktiv me metodën e gama-karotazhit.

Tipari kryesor i periudhës së mëvonshme, i fillimeve të viteve gjashtëdhjetë, ishte hopi drejt interpretimit të plotë sasior dhe cilësor i rezultateve të matjeve në pus, për të përcaktuar parametrat fizikë të horizonteve prodhimtarë të prerjeve terigjene, si poroziteti, përshkueshmëria dhe naftëngopja (Hidai Haxhi, Rushan Liço, Spiro Kozmai, etj.). Problem i ditës prej vitit 1961 u bë edhe studimi i prerjeve karbonatike Filloi të punohej në lidhje me përcaktimin e horizonteve kolektore në këto prerje dhe, qoftë edhe në mënyrë cilësore të vlerësohej naftëmbajtja e tyre dhe pozicioni i kontaktit naftë-ujë, etj. Në këtë kuadër u krye eksperimentimi dhe filloi përdorimi i mikrosondave, i sondeve simetrike, i karotazhit anësor etj. Në studimin e prerjeve të puseve, krahas gama-karotazhit (Pertef Nishani etj.), filloi edhe përdorimi i metodës së gama-gama karotazhit e karotazhit zanor.

Periudha e viteve shtatëdhjetë dhe gjysma e parë e viteve tetëdhjetë u karakterizua nga një zhvillim më i madh dhe i shumanshëm i studimeve gjeofizike të puseve në disa drejtime me kontributin e madh të Hidai Haxhi, Rushan Liço, Spiro Kozma, Nikolla Zendeli, Daver Çano, Kliti Verria, Nazif Kapedani, etj.:

a) Kompletimi i komplesit të studimit të puseve me metoda bashkëkohore: gamma-gamma karotazhi, karotazhi neutronik, aktivimi neutronik, përdorimi i gjurmuesve radioaktivë, karotazhi anësor, u zgjerua përdorimi i karotazhit gazor, etj. Për këtë u sigurua edhe aparatura e nevojshme e kohës.
b) Interpretim i sasior i të dhënave gjeofizike të studimit të puseve me anën e kompjuterave. Rezultatet e këtyre interpretimeve janë vënë në themel të studimit të të gjithë puseve të naftë dhe të gazit në vend.
c) Studimi i vetive fizike të shkëmbinjve të kolektorëve naftë-gazmbajtës.
d) Në ndërtimin e aparaturave dhe paisjeve automatike, që me sukses u vunë në përdorim, midis të cilave më të rëndësishmet janë stacioni automatik i karotazhit SAK-67 (Kristaq Papa, Kadri Zalla etj.), stacioni i karotazhit zanor (1969), stacioni automatik i performimit dhe marrjes anësore të kampioneve (SAPK-70/1) (1970), termometra elektrike diferencialë, mikrosonda, perforatiorë kumulativë, aparaturë pusi për gama-karotazhin dhe lokatorë magnetikë.

Ky nivel i arritur lejoi që të studioheshin mirë dhe me siguri e cilësi kolektorët karbonatikë dhe terrigjenë naftë-gazmbajtës, duke përdorur metoda të përparuara të kohës. Me këtë u dha një kontribut me vlerë shumë të madhe për njohjen e shtratimeve të naftës dhe të gazit në gëlqerorë dhe ranorë, si gjatë kërkimit të vendburimeve të reja ashtu edhe në nxjerrjen e naftës dhe të gazit në vendburimet ekzistuese.

Studimi gjeofizik i shpimeve u krye edhe gjatë kërkim-zbulimit të vendburimeve të mineraleve të dobishme të ngurta.

Duke filluar nga viti 1959, ekspedita gjeofizike e Ndërmarjes Gjeologo-Topografike, Tiranë, filloi përdorimin e karotazhit elektrik për studimin e puseve të shpuar në vendburimet e qymyreve, të bakrit, hekur-nikelit etj. Ky drejtim i studimeve gjeofizike të shpimeve u zgjerua dhe u kompletua me metoda të kohës ne vitet shtatëdhjetë-tetëdhjetë. Për studimin e puseve në vendburimet e qymyreve në të gjitha pellgjet qymyrore të vendit u përdorën metodat të karotazhit elektrik, gama dhe gama-gama karotazhi, inklinometria etj. Kontribut i madh në këtë drejtim dhanë Neim Çavani dhe Sillo Muçko. Zbulimi i vendburimit të qymyreve në Mushqeta është një ndër sukseset e rëndësishëm të punës kërkuese të Neim Çavanit. Për stuidmin e shpimeve në vendburimet e bakrit dhe të kromit u përdorën karotazhet e rezistencës, karotazhi i polarizimit të provokuar, gama dhe gama-gama karotazhi.

Studimi gjeofizik i puseve të shpuar në vendburimet e fosforiteve nuk është kufizuar vetëm me caktimin e thellësisë dhe potencës së horizontit fosfatik bëhej edhe vlerësimi sasior i përmbajtjes së P_2O_5 në mineral.

Aktualisht edhe ky drejtim i gjeofizikës është shuar pasi nuk shpohen më puse kërkim-zbulimi. Ka mbetur vetëm një bërthamë e vogël në industrinë e naftës, për të studiuar ndonjë pus të ALBPETROLIT.

9. BASHKËPUNIMI SHKENCOR

Arritjet e gjeofizikës shqiptare janë siguruar nga njëbashkepunjim shkencor i frytshëm midis institucioneve dhe specialiteteve të ndryshme të vendit: qendrave gjeofizike, ndërmarjeve dhe institucioneve gjeologjike, univesitetit dhe instituteve të Akademise së Shkencave. KLy bashklëpunim konsiston në:

- Projekte të perbashketa gjeologo-gjeofizike-gjeokimike, sollën zbulimin e dhjetra vendburimeve të nafte, të gazit, të bakrit, të kromit, të fosforiteve, të qymyreve etj.
- Bashkëpunimi me INIMA kijoi kushte për futjen e metodave mathematike në përpunimin dhe interpretimin e të dhënave gravimetrike, magnetometrike, elektrometrike etj.
- Bashkëpunimi me Institutin e Fizikës Bërthamore krijoi mundesitë për studimet radiometrike dhe analizat gama-spektrometrike, si edhe analizat me aktivim neutronik.
- Formimi i inxhinjerëve të rinj dhe kualifikimi pasunivertsitar, duke angazhuar specialistet më të kualifikuar të vendit si pedagoge të jashtem.
- Angazhimi i profesoraturës së Katedrës së Gjeofizikës, Fakulteti I Gjeologjisë dhe Minierave, në kërkimin shkencor të qendrave gjeofizike të vendit, si edhe në projektimet për kërkimin e vendburimeve të naftës e të gazit, si edhe të mineraleve të tjera të dobishme.

Pjesa e dytë

PËRGATITJA E INXHINJERËVE GJEOFIZIKË DHE KUALIFIKIMI I TYRE PASUNIVERSITAR.

Përgatitja e inxhinjerëve gjeofizikë filloi me dy kurse në vitin 1961 në Degën e Gjeologjisë të Fakultetit të Inxhinjerisë në Universitetin Shtetëror të Tiranës, duke nisur nga kursi i katert, me kontigjentin e studentëve që u kthyen nga jashtë shtetit dhe studionin për gjeofizikë. Trembëdhjetë inxhinjerët e parë gjeofizikë u diplomuan në vitin 1963. Krahas këtij kursi, u hap edhe një kurs nga viti e tretë, me studentë që kishin kryer studimet në vitin e dytë në Degën e Gjeologjisë, të cilët u diplomuan në vitin 1864. Pas kësaj u ndërpre përgatitja e inxhinjerëve gjeofizikë deri në vitin 1978 kur u rifilloi përsëri. Përgatitja e inxhinjerëve gjeofizikë bëhej në kuadrin e Katedrës së Vendburimeve dhe të Metodave të Kërkimit. Me ndërpreje, deri më sot përgatitja e inxhinjëreve gjeofizikë kaloi disa etapa:

Në vitin 1968 u formua katedra e Gjeofizikës në Fakultetin e Gjeologjisë dhe të Minierave. Në vitin 1992 Katedra shdërrohet në Seksion, dhe inkuadrohet në kuadrin e Departamentit të Shkencave të Tokës. Në këtë pozicion mbetet edhe pas ndryshimeve të bëra në vitin 2005 në kuadrin e Protokolit të Bolonjës.

Duke filluar nga viti 1962 e nw vazhdim wshtw kryer edhe kualifikimi pasuniversitar i inxhinjereve sipas skemave:

Kualifikimi pasuniversitar, titujt dhe gradat shkencore ne universitet:

Gjatë periudhës 1957-1992 është realizuar si më poshtë:

Profesor (pas Dr.Shk., shkalla e dytë) minimum. 2 vjet
Docent (pas Kandidatit të Shkencave) minimum. 4 vjet
Pedagog i parë minimum 4 vjet
Pedagog i dytë minimum 4 vjetAsistent

Aspirantura: *Kandidat i Shkencave* (Shkalla e parë e kualifikimit pasuniversitar) Minimum 3 vjet

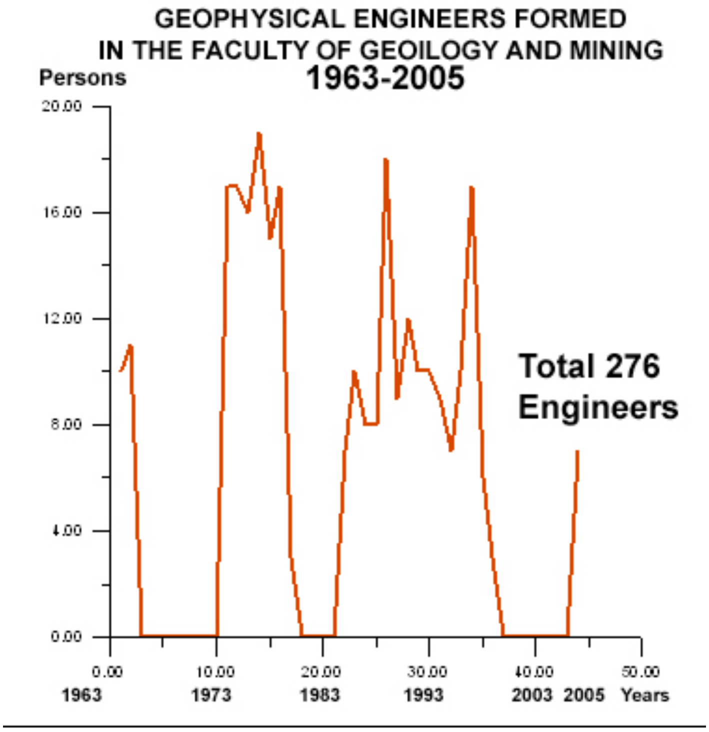
Gjate periudhes 1992 e deri aktualisht:

Profesor (pas Dr.Shk.) minimum. 2 vjet
Profesor i asociuar (pas Doktor i Shkencave) minimum. 4 vjet
Pedagog minimum 4 vjet

Asistent

Shkolla Pasuniversitare (SHPU)- Doktor i Shkencave
Minimum 1 vit SHPU dhe 3 vjet doktorata

Nga dega e gjeofizikës janë përgatitur 276 inxhinjerë gjeofizikë dhe janë specializuar për gjeofizikë dhjetra fizikanë me kurse një vjeçare pasuniversitare, ose në kuadrin e kualifikimit pasuniversitar.



Gjatë periudhës 1973-2005 janë kualifikuar dhe kanë marrë tituj e grada shkencore 74 specialistë gjeofizikë:

Dr. shkencash	45
Profesorë	7
Prof. As.	1
Drejtues Kërkimi	9
Mjeshter Kërkimi	12

Gjatë viteve janë kryer edhe kurse specializimi me inxhinjerë gjeofizkë e gjeologë për përpunimin e të dhënave me anën e kompiuterave, për gjeofizikën inxhinjerike dhe mjedisore, si edhe për kërkimin e ujërave.

MBI PLANET MËSIMORE TË PËRGATITJES SË INXHINJERËVE GJEOFIZIKË

Gjatë periudhës 1961-2005 janë hartuar dhe përmirësuar vazhdimisht planet mësimore, që ato tu përgjigjen sa më mirë kërkesave të kohës dhe nivelit shkencor dhe teknologjik të kërkimeve e studimeve gjeofizike.

Gjatë këtyre viteve, planet mësimore kanë ndryshuar si strukturë dhe si vëllim dijesh. Ndryshimet thelbësore janë si më poshtë vijon:

Në vitin 1967 deri 1992 dhe 1999-2005, inxhinjeri gjeofizik pergatitej si specialitet i veçante, duke marre te plota lendet teorike bazë në veçanti fizike e matematikë, lendet formuese gjeologjike dhe lëndët e specialitetit.

Në vitin 1974, në planin mësimor të degës së gjeofikës, u fut për herë të parë në Universitetin e Tiranës, lënda e teknikes llogaritese, e cila me von u riemërua: Informatika dhe programimi.

Në vitin 1985 u fut për herë të parë lënda e re e "trajtimit të sinjalit".

Pas vitit 1992 u futën si lëndë opsionale Gjeofizika inxhinjerike dhe e mjedisit, duke zgjeruar me këtë fushën e zbatimeve gjeofizike dhe sjelljen në nivel të kërkesave bashkëkohore ndaj gjeologëve dhe gjeofizikëve.

Me reformën e revolucionaizimit të shkollës dhe trekëndëshin revolucionar mësim-punë praktike-stërvitje ushtarake, në planet mësimore pas vitit 1967 u pakësua vëllimi i lëndëve inxhinjerike si edhe i atyre gjeologjike.

Me futjen e sistemit të biennales për dy vitet e para të Universitetit Politeknik, pas vitit 1992 dhe me mbylljen e degës së gjeofizikës, në opsionin e specilitetit gjeofizik u pakësua vëllimi i njohurive të marra për lëndët e specialitetit gjeofizik, krahas edhe me rradhën e përshtatshme të zhvillimit të disa lëndëve gjeologjike.

Ndryshime thellbësore u bënë në vitin 2005, me zbatimin e Protokollit të Bolonjës, të cilat do të analizohen pas paraqitjes së planeve të reja mësimore, më poshtë.

Në tabelën e mëposhtme krahasohen me detaje planet mësimore të periudhave të ndryshme të treguara më lart.

PLANET MESIMOR TE DEGES SE GJEOFIZIKES NE VITE 1961-2005

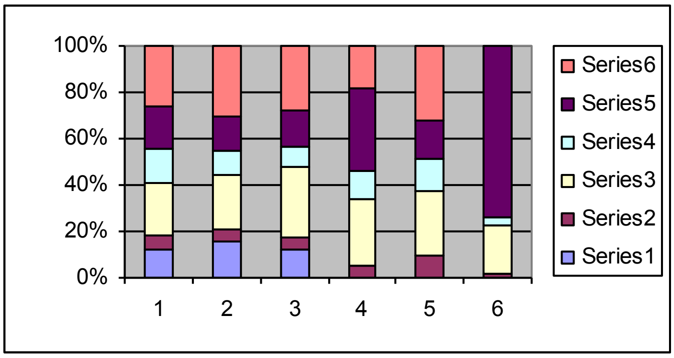
Nr.	Lenda	Vitet					
		1961-1964	1978-1983	1987	1992-1996	2000-2005	Shenime
	Lende politiko-ushtarake						
1	Histori e PPSH	112	112	120			
2	Ekonomi politike	112	112	120			
3	Materializem dialektik dhe historic	132	132	142			
4	Mesim Ushtarak	120	214	148			
	Lende sociale						
	Sociologji				45	45	
5	Edukate fizike	110	110	120	60	120	
6	Gjuhe e huaj	110	110	120	120	240	
	Lende teorike baze						
7	Algjeber dhe gjeometri analitike		112	135	120	120	
8	Analize matematike e numerike		342	542	485	330	
9	Statistike e probabilitet				75	75	
10	Ekuacione speciale te fizmat.		56			70	
11	Informatike			90		120	
12	Gjeostatistike				75	48	
13	Fizike		287	390	240	255	
14	Kimi e pergjitheshme dhe fizike		65	120	120	120	
15	Trajtim sinjalesh			84	135	90	
	Lende inxhinjerike						
16	Gjeodezi dhe markshejderi	120	82	75	75	75	
17	Gjeometri descriptive dhe vizatim teknik	68	68	60			
18	CAD				60	45	
19	Grafike inxhinjerike					135	
20	Mekanike teorike, inxhinjerike	60			120	120	
21	Rezistence materialesh				60		

22	Mekanika e mjedisit te vazhduar				75		
23	Elektroteknike dhe elektronike e zbatuar	154	154	150	90	90	
24	Sistemet gjeoinformative (GIS)					60	
25	Teknologji minerare dhe shpim	168	78	84	60	75	
	Lende gjeologjike						
26	Gjeologji pergjitheshme		68	60	75	75	
27	Paleontologji, Stratigrafi dhe Gjeologji historike			60	195	60	
28	Gjeomorfologji – gjeologji kuaternarit					36	
29	Kristalografi dhe kristalo optike				105		
30	Mineralogji-petrografi		112	120	285	120	
31	Gjeologji strukturore dhe gjeotektonike		112	135	170	111	
32	Hartografim Gjeologjik				60		
33	Gjeodinamike				75		
34	Bazat e gjeokimise				75		
35	Gjeologji e vb dhe kerkimi tyre		106	112	168	120	
36	Metalogjenia				55		
37	Gjeologjia e naftes dhe kantierale		134	153	75	144	
38	Gjeologjia e Shqiperise				60		
38	Hidrogjeologji dhe gjeologji inxhinjerike		48	56	150	60	
	Lende gjeofizike						
40	Bazat e gjeofizikes		70		75		
41	Magnetometri		106	125	43	105	
42	Gravimetri		114	123	50	91	
43	Elektrometri		154	211	104	196	

44	Teoria valeve dhe sizmika		198	233	185		
45	Teori e valeve, sizmike e sizmologji					274	
46	Gjeofizika e puseve		176	234	104	194	
47	Fizika berthamore e radiometria		116	98	45	133	
48	Aparature gjeofizike			65			
49	Fizika e Tokes				60	60	
50	Perpunim i te dhenave gjeofizike me kompiuter		106	70			
51	Organizim planifikim i punimeve gjeofizike		36	70			
52	Bazat e ekonomise se tregut				44	60	
53	Vetite fizike te mineraleve dhe shkkembinjve	60					
54	Sizmometri	60					
55	Lende me zgjedhje: Probleme te kerkimit te mineraleve me gjeofizike		48		33	77	
56	Lende me zgjedhje: Probleme te studimit te rezervuareve					77	
57	Lende me zgjedhje: Gjeofizika inxhinjerike					77	
58	Lende me zgjedhje: Gjeofizika nentokesore				33		
59	Lende me zgjedhje: Gjeofizika e mjedisit				33	60	
	GJITHESEJ	4092	3738	4425	4372	4363	
	Praktike ne terren: (Jave						
1	Geologji e	2	2	2			

	pergjitheshme						
2	VrotjimeTopografike	2	2	2			
3	Gjeologji strukturale, hartografim	2	2	2	2	3	
4	Kerkim Gjeologjik1	8	4	4	2	2	
5	Stazh ne Ndermarrje		36	36			
6	Praktike Diplome	8			4	4	
	Total	22	46	46	8	9	
	Stervitje ushtarake (jave)	8	20	20			

Në grafikun e më poshtëm paraqiten ndryshimet e treguara më lart.



Lëndët sipas serive : 6. Gjeofizike; 5. Gjeologjike; 4. Inxhinjerike; 3. Teorike të përgjithëshme bazë; 2. Sociale; 1. Politike dhe përgatitje ushtarake.PS: Programi mësimor i zbatuar në vitin 2005 sipas Protokollit të Bolonjës i përket tre viteve të para, për Diplomën Bachelor.

Lwndwt sipas programeve:

Njohuritë gjeofizike, siç duket ngjatë viteve janë plotësuar dhe kanë pësuar ndryshimet e duhura në planin dhe në programet mesimore, duke iu përgjigjur nivelit teknik-shkencor dhe teknologjik të gjeofizikës. N:

Lëndët e specialitetit gjeofizik: Vite 1961-1964 1973-1978 1987-1996 2000-2005

Magnetometri	+	+	+	+
Gravimetri	+	+	+	+
Elektrometri	+	+	+	+
Teori e valëve sizmike	+	+	+	+

Sizmikë	+	+	+	+
Teori e valëve-sizmikë-sizmologji				+
Sizmikë stratigrafike				+
Sizmikë inxhinjerike				+
Studimi gjeofizik i puseve	+	+	+	+
Radiometri	+	+	+	+
Trajtim sinjali		+	+	+
Fizikë e Tokës			+	+
Përpunimi i të dhënave gjeofiz. me kompiuter		+	+	+
Geofizikë inxhinjerike				+
Gjeofizikë mjedisore			+	+
Gjeofizika në Miniera			+	+
Gjeotermi				+

Lënde Gjeofizike për specialitetet jo Gjeofizike në Fakultet:Metodat gjeofizike të kërkimit
Studimi gjeofizik i puseve
Gjeofizikë inxhinjerike dhe e mjedisit

Njohuritë teorike bazë jepen kryesisht me lëndët fizikë, matematikë, kimi dhe disa lëndë të përgjithshme gjeologjike. Përmirësimi i njohurive të marra në kë lëndë ka qënë në qëndrën e vëmendjes së Seksionit të Gjeofizikës:

Periudhat	1961-1964	1973-1978	2002-2005
Analizë matematike	+	+	+
Gjeometri analitike	+	+	+
Ekuacionet speciale të Fiz. Mat. dhe funksionet specialë	+	+	+
Algjebra lineare		+	+
Statistikë dhe probabilitet		+	+
Gjeostatistikë			+
Informatikë programim		+	
Analizw numerike	+		+

Plani mësimor gjatë viteve 1992-1996, për bienalin ka qene: - Analizë matematike - Fizikë atomike dhe bërthamore
- Gjeometri analitike - Kimi
- Algjebër lineare - Gjeologji e përgjithëshme
- Ekuacionet e fiz.- mat. - Gjeometri deskriptive
- Metodat numerike
- Informatikë
- Fizikë e përgjithëshme

ë ndryshim nga periudha e punës sipas bienalit, në planet e tjera të përgatitjes gjeofizike u është dhënë rëndësia e duhur dë ndryshme matematike,për të krijuar kushtet e duhura për asimilimin e thellë të njohurive fizike dhe të lëndëve të specialitetit gjeofizik:

•Paleontologji & Stratigrafi
•Mineralogji &Kristalografi
•Petrografi & Petrologji
•Geokimi
•Gjeologji strukturale dhe hartografim
•Gjeology e vendburimeve të mineraleve të dobishme të ngurta
•Gjeologji e naftës dhe e gazit
•Metalogjeni
•Kërkim-zbulimi i vendburimeve të mineraleve të dobishme të ngurta.
•Gjeologjia e rezervuarit.
•Gjeodinamikë
•Gjeologji e Shqipërisë
•Hidrogjeologji
•Gjeologji Inxhinerike
•Gjeologji Mjedisore

Në vitin 2005, pas analizimit të planeve mësimore të shumë universiteteve europianë dhe diskutimeve të shumta, në zbatim të Protokollit të Bolonjës u hartua plani i ri mësimor sipas parimit 3 vjet Diploma Bachelor +2 vjet Diploma Master + 3 Diploma Doktor i Shkencave. Aktualisht është hartuar plani mësimor për tre vjetët e parë, i cili ka filluar të zbatohet.

PLANI MËSIMOR, SIPAS PROTOKOLLIT TË BOLONJËS

(2005 është viti i parë i zbatimit)

Cikli 3 vjeçar Diploma BACHELOR

Viti i I^{rë} 60 CFU

Simestri i I^{rë}	30 CFU	Simestri i II^{të}	30 CFU
	Seria 1A	55.5 CFU	
Kimi e përgjithëshme dhe analitike	5.0	Fizikë dhe termodinamikë kimike	3.0
Matematikë e përgjithëshme	5.0	Hyrje në matematikën statistikore	4.0
Fizika 1	5.0	Fizika 2	4.0
Gjuhë e huaj	2.0	Vizatim teknik+CAD	2.0
Informatikë	4.5	Bazat e hartografimit	3.0
Gjeologji e përgjithëshme	5.0	Paleobiologji dhe paleontologji	5.0
Kristalografi gjeometrike Dhe kimi kristalore	3.5	Mineralogji e përgjithëshme dhe Sistemaatikëë	4.5
Total	30.0	Total	25.5

Seri 1B 4.5 CFU

Praktikë në terren

Gjeologji	3.0
Hartografim	1.5

Viti i II^{ë} 60 CFU

Simestri i 3^{të}	30 CFU	Simestri i 4^{të}	30 CFU
	Seri 2A	54.0 CFU	
Gjeokimi	5.0	Sedimentologji + Limnologji	6.0
Mikropaleontologji 1	5.5	Mikropaleontology 2	3.0
Mineralogji Optike	5.5	Stratigraphy + Gjeologji Historike	3.5
Gjeomfologji	4.0	Gjeomatikë 1	2.5
Petrologji	5.0	Fizikë e globit	6.0
Gjeologji strukturore	5.0	Metodat e analizes petrografike dh e Gjeokimi	3.
Total	30.0	Total	24.0

Seri 1B 6.0 CFU

Praktikë në terren

Gjeologji strukturale, Prerjet Gjeologjike (Hartografim)	3.0
Gjeomorfologji, Sedimentologji, Stratigrafi	3.0

Viti i III^{ë} 60 CFU

Simestri i 5^{të}	30 CFU	Simestri i 6^{të}	30 CFU
	Seri 3A	48.0 CFU	
Petrografia e shkembinjve magmatike	5.0	Vendburime metalore dhe minerale industriale	4.0
Petrografia e shkembinjve Sedimentare e metamorfike	6.0	Vendburimet e hidrokarbureve	3.5

Gjeologji e Shqiperise	4.0	Gjeofizike e zbatuart	5.5
Basenet sedimentare	3.0	Gjeologji e mjedisit	3.5
Tektonika	2.5	Menaxhimi i ndermarrjeve	2.0
		Gjeologji e kuaternarit+ risqet gjeologjike	5.0
		Gjeokimi e mjedisit	2.0
		Hidrogjeologji	2.5
Total	30.0		18.0

Seri 1B	6.0 CFU	
	Praktikë në terren	
	Gjeofizikë e zbatuar	1.5
	Vendburime, petrografi	4.0
	Gjeologji e Shqipërisë	1.5
	Total	7.0

Në kuadrin e këtij projekti, në muajin tetor 2005 u bë një vizitë studimore nga 2 ditore në Departamentet e Gjeologjisë dhe të Gjeofizikës të Universitetit të Studimeve të Triestes, të Universitetit të Studimeve të Barit dhe të Universitetit Aristoteli të Selanikut. Fillimisht, u referua për përgatitjen e inxhinjerëve gjeofizikë dhe kualifikimine tyre pasuniversitar në Fakultetin e Gjeologjisë dhe të Minierave, si edhe për fushat e kërkimit shkencor në Seksionin e Gjeofizikës së këtij Fakulteti (Aneksi 1). Përkatësisht, u diskutua mbi zbatimet e Protokollit të Bolonjës me Prof. Icilio Renato Finetti, Prof. Anna Del Ben, Prof. Gianmaria Zitto, Prof. G. Baldazarre. Prof. Schiavonne. Ne Universitetin e Barit ishte zbatuar Protokolli i Bolonjës për strukturën 3 vite Diplomë Bachelor + 2 vite Diplomë Master + 3 vite Diplomë PhD. Në Universitetin e Selanikut nuk ishte zbatuar kjo strukturë, se e gjenin të papërshtatëshme. Vërejtje për të shfaqën edhe profesorë të Universitetit të Barit, duke konkluduar se shkolla 3+2 nuk është ekuivalente me shkollën 5 vjeçare. U diskutua për kërkimin shkencor që realizohet në këta universitete. Gjatë qëndrimit në Trieste u bë një vizitë e shkurtër edhe në Observatorin Gjeofizik të Triestes OGS, ku u diskutua për mundësitë e kërkimit shkencor në kuadrin e projekteve të përbashkët bilateralë ose të komunitetit Europian.

Në pasqyrën e mëposhtme bëhet krahasimi i planit mësimor të Departamentit të Shkencave të Tokës në Fakultetin e Gjeologjisë dhe të Minierave të Universitetit Politeknik të Tiranës dhe Laurës në Shkencat Gjeologjike në Universitetin e Studimeve në Trieste, për tre vitet e parë, Diplomë Bachelor.

KRAHASIMI i PLANEVE MESIMORE TE STUDIMEVE
BACHELOR NË SHKENCAT E TOKËS

MIDIS FAKULTETIT TE GJEOLOGJISE DHE TE MINIERAVE TE UNIVERSITETIT POLITEKNIK TE TIRANES DHE UNIVERSITA DEGLI STUDI DI TRIESTE, ITALI

Total Bachelor 180 CFU

Viti Parë 60 CFU 1 Anno

Departamenti i Shkencave të Tokës, Fakulteti i Gjeologjisë dhe i Minierave			Universita degli Studi di Trieste Laura in Scienze Geologiche		
Lëndët	CFU	Orë	Lëndët	CFU	Orë
Matematikë e përgjithëshme	5.0		Instituzioni di Matematiche	8	64
Kimi e përgjitheshme dhe analitike	5.0		Chimica gen. ed inorganica con elem. Di organica	8	64
Fizika I+II	9		Fisica I e II modulo	8	32+32
Informatike	4.5		Informatica	3	30
Gjeologji e përgjitheshme	5.0		Introduzione alla Geologia	3	24
Mineralogjia e përgjithëshme dhe sistematika	4.5		Mineralogia	8	32+24 16
Gjuhë e huaj	2.0		Lingua straniera	3	24+36
Kristalografi gjeometrike dhe kristalokimi	3.5		Estimo	2	16
Hyrje në statistikën matematike	4.0		Geografia fisica con laboratoriu di cartografia	6	24
Termodinamikë fizike dhe kimike	3.0		Geologia del sedimentario con laboratorio	10	16+24+16
Vizatim teknik + CAD	2.0		Laboratorio di informatica	5	24 16
Bazat e hartografimit	3.0				
Paleobiologji dhe paleontologji	5.0				
Shuma	60.0			64	
Praktikë në terren					
Praktikë në gjeologji	3.0				
Hartografim	1.5				
Shuma	4.5				

PLANI I STUDIMEVE

BACHELOR NË SHKENCAT E TOKËS

Viti Dytë 60 CFU

Departamenti i Shkencave të Tokës, Fakulteti i Gjeologjisë dhe i Minierave			Universita degli Studi di Trieste Laura in Scienze Geologiche		
Lëndët	CFU	Orë	Lëndët	CFU	Orë
Semestri I[rë]					
Gjeokimi	5.0		Paleontologia con laboratorio	8	32+24 16
Mikropaleontologji	5.5		Geomorfologia	4	32
Mineralogjia optike	5.5		Petrografia con laboratorio	8	36 40+24
Gjeomorfologji	4.0		Fisica terrestre	7	40+24
Petrologji	5.0		Geochimica	4	32
Gjeologji strukturore	5.0				
Shuma	30.0				
Semestri II[të]					
Sedimentologji+limnologji	6.0		Tectonica e Geodinamica	7	32 24 16
Mikropaleontologji 2	3.0		Rilevamento Geologico	8	8 12 96
Stratigrafi + Gjeolgji historike	3.5		Topografia e cartografia	3	
Gjeomatikë I	2.5		Dirito admministrativo	2	20
Fizika e Globit	6.0				
Metoda e analizës petrografike e gjeokimike	3.0				
Shuma	24.0				
Praktikë në terren					
Gjeologji strukturale, prerje gjeologjike (hartografim)	3.0				
Gjeomorfologji, sedimentologji, stratigrafi	3.0				
Shuma	6.0				

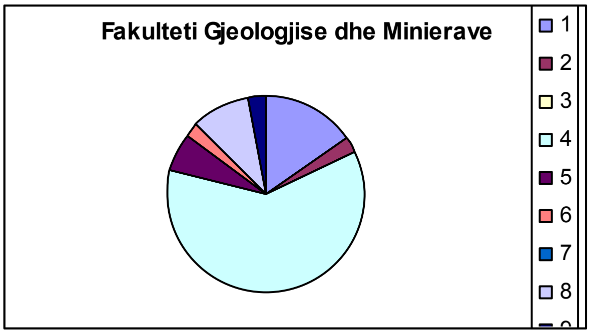
PLANI I STUDIMEVE

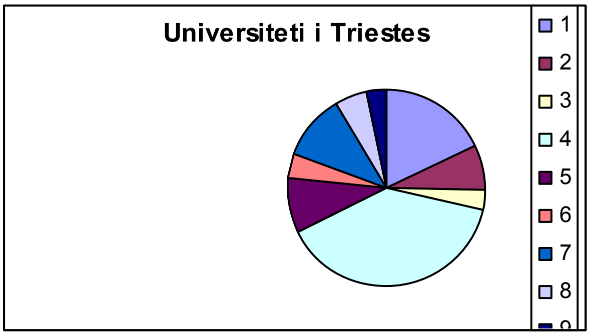
BACHELOR NË SHKENCAT E TOKËS

Viti Tretë 60 CFU

Departamenti i Shkencave të Tokës, Fakulteti i Gjeologjisë dhe i Minierave			Universita degli Studi di Trieste Laura in Scienze Geologiche		
Lëndët	CFU	Orë	Lëndët	CFU	Orë
Semestri I^rë					
Petrografia e shkëmbinjve magmatikë	5.0		Geofisica Applicata	10	48 36 16
Petrografia e shkëmbinjve sedimentare	6.0		Sistemi informative cartografici	3	8+12 12
Gjeologji e Shqipërisë	4.0		Meccanica delle roche	2	16
Basenet sedimentare	3.0		Geotecnica	4	
Tektonika	2.5		Geologia Applicata I Modulo	6	32+24
Gjeologjia e kuaternarit + risqet gjeologjike	5.0		A skelta dello studente	8	
Gjeokimi e mjedisit	2.0				
Hidrogjeologji	2.5				
Shuma	30.0				
Semestri II^të					
Vendburime metalore dhe minerale industriale	4.0		Scienza delle construzioni	2	
Vendburimet e hidrokarbureve	3.5		Geologia Applicata II Mod.	4	64
Gjeofizikë e zbatuar	5.5		Stage, tirocini, ulteriori conoscenze	9	
Gjeologji e mjedisit	3.0		Prova finale	6	
Menaxhimi i ndërmarrjeve	2.0		Totale di crediti III anno	53	
			Totale per i tre anni	180	
			Corsi optionali Laura Trienale Scienze Geologiche		
Shuma	18.0		Rocce e materiali per l'industria	5	
			Idrogeologia	4	32
Praktikë në terren			Georisorse minerale	4	32
Gjeofizike e zbatuar	1.5		Micropaleontologia	4	24+12
Vendburime, petrogr.	4.0		Mineralogia applicata	4	24+12
Gjeologji e Shqipërisë	1.5		Criteri di intervento sul territorio	3	24
			Lab. di analisi sedimentologia	3	36
Diploma e Bachelor-it			Geologia del Quaternario	4	24+16
Mbledhje të dhënash + kampionesh	2.0		Sedimentologia	4	32
Shkrimi dhe prezantimi i diplomës	3.0		Petrografia applicata	4	24+12
Shuma	5.0		Geochemica applicata	4	32

Në figurën e mëposhtme bëhet ballafaqimi grafik i këtyre dy planeve mësimore, sipas grupeve të lëndëve:





Lëndet: 1- Teorike të përgjithëshme bazë; 2- Inxhinjerike; 3- Natyrore; 4- Gjeologjike; 5- Gjeofizike; 6- Sociale; 7- Punë e pavarur;`8- Stazhe; 9- Diploma

Meqenëse gjatë viteve të ardhshëm do të përgatitet edhe plani mësimor për diplomën e masterit, gjatë vizitave studimore u kushtua vëmendje edhe këtij problemi. Universiteti i Triestes ka dy drejtime gjeofizike për laurën e specialistit në gjeofizikë: Gjeofizika teorike dhe eksperimentale dhe Gjeofizika e zbatuar.

Në pasqyrën e nëposhtme paraqitet plani mësimor i dy vjetëve , të 4 dhe të 5-të. (Universiteti Triestes)

Insegnamenti	CFU	Tipologia di attivita	Ore
S = Suppienza; A=Affidamenti; M= Mutuazione; C=Contratto			
Insegnamenti in commune ai due percorsi della Laurea Specialistica Geopfisica			
Probabilita e statistica	4	a	32
Introd. Al calcolo numerico	4	a	32
Acustica	6	a	48
Metodi di tratt. Del segnale	5	b	48
Geologia II parte A	4	c	16+24
Geologia II parte B	4	b	16+12+16
Idrogeologia applicata	6	c	48
Stages, tirocini, ulteiaori conosenze	3	f	
Prova finale	30	e	
Percorso Geofisica Teorici-Sperimentale			
Vulcanologia	4	b	32
Geodesia	6	b	48
Seismologia applicata	4	g	32
Sismometria	5	g	32+12
Sismologia A	6	b	48
Sismologia B	6	b	48
Oceanografia A	6	b	32
Gravita e magnetismo	4	b	32
Lab. di tecnica del suono	6	a	48
Elettromagnetismo	7	b	90
Percorso Geofisica Applicata			
Laboratorio di acquisizione e Tratamento dati eofisici	6	b	36+48
Logs e prospezioni geofisici	5	g	16+24
Lavoratorio di interpretaz. E inversione dati geofisici	6	b	72
Electromagnetismo	6	a	48
Metodi di trattamenti delle immagini	5	b	48
Geofisica mabientale	6	b	40+20
Prospezioni geofisiche	4	g	32
Oceanografia A	4	b	32
Lab. di tecnica del suono	2	b	16
Interpretazione dati sizmici	6	b	32+24
Monitoragio delle acque e dei sedimenti	4	b	16+16
Total	120		

Ky kurrikulum, krahas edhe të tjerëve nga universitete të ndryshme europiane, mund të shërbejë si orientues për hartimin e kurrikulave së specialitetit gjeofizik në Fakultetin e Gjeologjisë dhe të Minierave për diplomën e masterit.

Në kuadrin e diskutimeve për zbatimin e Protokollit të Bolonjës, nga profesorë të Fakultetit të Shkencave të Natyrës, është bërë edhe propozimi që për diplomën e masterit në gjeofizikë mund të vijnë edhe studentët që janë diplomuar "Bachelor në fizikë". Lidhur më këtë propozim e shohim të domosdoshme të theksojmë:

a) Gjeofizika ka si objekt studimi Tokës, historinë e formimit dhe zhvillimit të saj, dinamikën e ndryshimeve në kohë, si edhe kërkimin e vendburimeve të mineraleve të dobishme dhe njohjen e gjeomjedisit.

b)Specialiteti i gjeofizikës mbështetet mbi tri shtylla të dijeve: 1) matematikë-fizikë - kimi; 2) Shkencat e Tokës (disiplinat gjeologjike dhe gjeofizike) dhe 3) Disiplinat inxhinjerike. Njohuritë gjeologjike të shtrira në tre vitet e para zënë 140 kredite në Fakultetin e Gjeologjisë dhe të Minierave dhe 132 kredite në Universitetin e Triestes, nga 180 kredite gjithësej te tre viteve të para të diplomës bachelor.

Këtej rezulton se:
1) Për të bërë masterin në gjeofizikë mund të vijnë studentë edhe nga degët e fizikës, të matematikë, të elektronikës etj., por përpara se të fillojnë studimet për masterin ata duhet të plotësojnë dijet gjeologjike në masën e 140 krediteve, ose të 2,3 vite studimi.

Disiplinat gjeologjike ne Universitetin e Triestes per tre vitet e para:

Introduzione alla Geologia	3 kredite
Mineralogia	8
Geologia del sedimentario con laboratorio	10
Paleontologia con laboratorio	8
Geomorfologia	4
Petrografia con laboratorio	8
Fisica terrestre	7
Geochimica	4
Tectonica e Geodinamica	7
Rilevamento Geologico	8
Geofisica Applicata	10
Meccanica delle roche	2
Geotecnica	4
Geologia Applicata i	4
Geologia Applicata II	4
Rocce e materiali per l'industria	5
Idrogeologia	4

Georisorse minerale	4
Micropaleon tologia	4
Mineralogia applicata	4
Criteri di intervento sul territorio	3
Lab. di analisi sedimentologia	3
Geologia del Quaternario	4
Sedimentologia	4
Petrografia applicata	4
Geochemica applicata	4
Total	**132 kredite**

Kjo sjell që diploma e masterit të merret pas 7 vitesh, ç'ka është e papërshtatshme dhe jo logjike.

2) Edhe në Shqipëri, si kudo në vendet e tjera, për realizimin e projekteve gjeofizike punohet në ekipe komplekse: gjeofizikanë, gjeologë, mineralogë e petrografë, gjeokimistë, informaticienë e matematikë, fizikanë, etj. Por secili nga këta specialistë, sipas nevojës, mbulon problemet e fushës së vet. Në Shqipëri, në mungesë të numrit të mjaftueshëm të gjeofizikanëve kanë punuar, kryesisht në industrinë e naftës, edhe fizikanë të cilët janë specializuar në vite, si edhe me kurse të rregullt një vjeçarë pasuniversitarë në katedrën e gjeofizikës, pa u konvertuar në gjeofizikë dhe vetëm pas kësaj kanë bërë Shkollën Pas Universitare (SHPU).

3) Propozime të tilla të pastudiuara dhe të papërgjegjëshme sjellin vetëm çoroditje në mendjen e studentave, si edhe krijimin e "masterave në shkencën e gjeofizikës" të pa pajisur me njohuritë e domosdoshme mbi të cilat ngrihet godina e dijeve të gjeofizikut.

Mësimet praktike dhe punët laboratorike

Deri në fundin e viteve tetëdhjëtë sudentët e gjeofikës kishin në dispozicion tekste për zhvillimin e mësimeve praktike dhe ushtrimeve, dhe megjithëse shumë pak edhe bazë kompiuterike dhe softëare të hartuar nga profesorë të katedrës dhe te INIMA-s, që u krijonin mundësi për të zgjidhur ushtrime individualisht, ndonse në kohë të kufizuar. Ne atë periudhë (1984-1985), Laboratori i Gjeofizikës u pajis edhe me aparaturë moderne të prodhimit kanadez dhe suedez, në kuadrin e projektit të UNESCO-s. Kjo aparaturë krijoi mundësinë e punës së pavarur të studentëve për zhvillimin e punëve laboratorike të nivelit bashkëkohor.

Ndërrimi i bazës kopiuterike, së toku dhe me softëare standard për to, nxorri jashtë pune edhe softëaren gjeofizike, të hartuar nga katedra, mbi bazën e gjuhëve dhe të programeve që nuk i njiohin kompiuterat e sotme. Sot kërkohet rindërtimi i saj për programet që

njohin kompiuterat aktualë dhe metodikat që përdor sot gjeofizika për përpunimin dhe interpretimin e informacionit gjeofizik.

Siç është e kuptueshme, pas mbi 20 pune, aparatura e laboratorit të gjeofizikës është e amortizuar moralisht dhe fizikisht. Ajo nuk i përgjigjet nivelit të aparaturave që përdor sot gjeofizika, për fat të keq. Kjo kufizon punët laboratorike që zhvillohen vetëm për disa lëndë të specialitetit, të kufizuara kryesisht për demonstrime të dukurive gjeofizike të ndryshme.

Fushat e kërkimit shkencor në Seksionin e Gjeofizikës për periudhën 1961-2005

Profesorët dhe pedagogët e Seksionit të Gjeofizikës kanë ndërthurur mjaft mirë veprimtarinë e tyre pedagogjike me atë kërkimore shkencore gjatë gjithë periudhës 1961-2005. Kjo veprimtari është kryer në kaudrin e Programeve Kombëtare për Kërkim e Zhvillim dhe të emërtesës së Këshillit të Ministrave, Programeve shkencorë të Komunitetit Europian, e realizuar sipas projekteve të drejtuar nga profesorët e Seksionit ose duke qenë bashkautorë në projekte të përbashkët me Seksionin e Shkencave Natyrore e Teknike e Akademisë së Shkencave dhe të institucioneve gjeologjike të tjerë te vëndit, si Shërbimi Gjeologjik Shqiptar dhe Qëndra Skencore Kombëtare e Hidrokarbureve (ish Instituti Gjeologjik e Naftes dhe i Gazit, Fier).

Veprimtaria shkencore është realizuar në disa drejtime kryesore;

1. Gjeofizika minerare: Për kërkimin e xeheroreve të bakrit, të kromit, të boksideve,etj. drejtuar nga pedagogët efektivë dhe të jashtëm të Seksionit:

1. Eksperimentimi i zbatimit të metodave të reja gjeofizike në Shqipëri:

• Metoda e polarizimit të provokuar (1962 e në vazhdim) (Lubonja L., Frashëri A.)

•Mikrorilevimet magnetike (1967) (Frashëri A)

•Prerja reale e IP dhe RD (1978 e në vazhdim) (Alikaj P)

•Rritja e thellësisë së kërkimeve gjeofizike të mineraleve xeherorë (1984 e në vazhdim) (Lubonja L., Frashëri A., Avxhiu R., Alikaj P., Bushati S.)

2. Modelime mathematike e fizike gjeofizike për elektrometrinë, gravimetrinë dhe magnetometrinë, si edhe problemi i inversionit gjeofizik. Hartimi i algoritmave dhe i programeve standard për përpunimin e të dhënave të këtyre metodave me kompiuter, si edhe botimi i tyre në tekstet “Elektrometria” dhe “Gravimetria” (Mësime praktike) (Nga1972 e në vazhdim) (L. Lubonja, A. Frashëri, S. Bushati, P. Alikaj, G. Beqiraj, N. Frashëri)

Studimet e fundit:

- Skemat Dipol – dipol dhe pol-dipol për vrojtimet elektrometrike në kuadrin e teoremës së reciprocitetit URL në Internet
URL në Internet
http://www.inima.al/~nfra

- Disa konsiderata për Inversionin e të dhënave të vrojtimit me metodën e Polarizimit të Provoluar.

3. Zgjerimi i fushës së zbatimit të metodave gjeofizike për kërkimin e:
- kromit,
- asbestit,
- boksideve,
- shkriferimeve të mineraleve të rëndë, të rrallë e të çmuar,
- Kontrolle gjeofizike gjeoteknike inxhinjerike dhe mjedisore,
- Kërkime hidrogjeologjike,

- Zbatimi i metodës së fushës elektrike natyrore për kërkimin e drejtpërdrejtë rezervuarëve të naftës dhe të gazit.

4. Pjesëmarrje në përgjithësime gjeologo-gjeofizike dhe projektime për kërkimin e naftës dhe të gazit (1973-1992) (Lubonja L., Nishani P., Frashëri A.).

5. Gjeofizika detare (1974-1990) (Frasheri A., Cani R., Luga Y.):
- Projektimi dhe ndertimi i stacionit te elektrometrise detare ne Uzinen elektromjekesore. Montimi i stacionit ne anije (Frasheri A., Canga B.)
- Sondime dhe profilime elektrike detare
- Studimi gjeologo-gjeofizik i shelfit shqiptar te Adriatikut.

6. Studime krahinore gjeofizike (1967 e në vazhdim).

6.1. Studime gjeotermale (1989 e në vazhdim) (Frasheri A., Liço R., Bushati S.)

Atlasi i Burimeve Gjeotermale në Shqipëri. 2004. ku janë paraqitur:
- Hartat e Temperaturës së Shqipërisë në thellësinë 100; 500; 1000; 2000; 3000 m.
- Harta e Gradientit Gjeotermal të Shqipërisë.
- Harta e Dendësisë së Fluksit të Nxehtësisë të Shqipërisë.
- Harta e Burimeve të Energjisë Gjeotermale të Shqipërisë.

Janë parashtruar rrugët e përdorimit të energjisë gjeotermale në Shqipëri.

URL në Internet

http://www.inima.al/~nfra/projects/geothermal/AlbanianGeothermalAtlas.pdf,

6.2. Studime paleomagnetike (1989-1997) (Frashëri A. Bushati S., Alikaj P.)

6.3. Harta e fushës së gravitacionit dhe asaj magnetike në shkallën 1:200.000 hartimi i të cilave është drejtuar nga Prof. Bushati S. Dhe realizuar nga Qendra Gjeofizike-Gjeokimike e Shërbimit Gjeologjik Shqiptar.

7. Studimi gjeofizik i puseve dhe i trysnive mbinormale (Liço R.).

8. Gjeofizika Inxinjerike dhe e Mjedisit (Nga 1982 e në vazhdim), (Frashëri A., Nishani P., Alikaj P., Bushati S.). Në përgjigje të kërkesave të kohës dhe të drejtimeve të zhvillimit të gjeofizikës në dy dhjetëvjecarët e fundit, është punuar suksesshëm për krijimin e gjeofizikës inxhinjerike dhe mjedisore edhe në Shqipëri. Për këtë është puniar në shumë fusha:

- Tomografia in-situ gjeoelektrike dhe sizmike:
- Kontrolli i digave.
- Qëndrueshmëria e shpateve dhe studimi i rrëshqitjeve.
- Vlerësimi iimpakteve mjedisore.
- Kontrollet e truallit dhe të shkëmbinjve në zonat e digave
- Kërkimi i zonave karstike.
- Kontrollet e truallit dhe të shkëmbinjve në zonat e autostradave, tuneleve etj.
- Vlerësimi i cilësisë së betoneve gjatë punimeve të ndërtimit, në pista të aeroporteve etj.
- Kërkimet e ujërave

Studimi i vendgrumbullimeve të mbeturinave urbane dhe industriale.

Rezultatet më të mira të këtyre studimeve janë botuar në periodikun shkencor brenda dhe jashte vendit, si edhe janë referuar me sukses në konferenca e kongrese shkencore në vend dhe ndërkombëtare.

Botimi i teksteve mësimore dhe monografitë

Deri në vitin 1985, Katedra e Gjeofizkës kompletoi të gjitha lëndët me tekstet mësimore, të botuara në periudhën 1971-1885, duke u krijuar studentëve kushtet për përvehtësimin e mirë të dijeve, si edhe për të rritur punën e pavarur, edhe me anën e teksteve për mësimet praktike dhe ushtrime:

Për degën e gjeofizikës
Gravimetri, pershtatje
Gravimetri, Ushtrime

Magnetometri, pershtatje
Elektrometria
Elektrometria, Mesime praktike, ushtrime
Teoria e valeve
Sizmika
Metodat gjeifizike te studimit te puseve
Radiometria
Perdorimi I metodave gjeofizike per zgjidhjen e detyrave gjeologjike
Vetite fizike te mineraleve dhe shkembinjvbe
Aparaturat gjeofizike
Disa aparate per vrojtimet elektrometrike me rryme te vazhduar

Për degën e gjeologjise dhe të inxhinjerëve të naftës dhe të minierrave
Metodat gjeofizike të kërkimit: v. 1. Gravimetria
v. 2. Magnetometria
v. 3. Elektrometria
v. 4. Sizmika dhe radiometria
Metodat gjeofizike te studimit te puseve
Gjeofizikas ne miniera

Krahas teksteve mësimore, u botuan edhe monografi për problemet të rëndësishme të zbatimit të gjeofizikës.

Monografi të botuara:
- Karsti dhe metodat gjeofizike te kerkimit. 1985, Shtepia Botuese e Universitetit, Tirane. N. Konomi, A. Frasheri, M. Muco, L. Kapllani, S. Bushati, L. Dhame.
- Probleme gjeofizike dhe gjeokimike per kerkimin e kromiteve dhe te bakrit. 1993, Shtepia Botuese e Universitetit, Tirane. E. Pumo, A. Frasheri, A. Tashko.

a) Atlasi i burimeve gjeotermale ne Shqiperi. 2004. Botuar nga Fakulteti I Gjeologjise dhe i Minierave. Autore A. Frasheri, V. Çermak, Rushan Liço, Nazif Kapedani, Fiqiri Bakalli, Burhan Çanga, Enkeleida Jareci, Edlir Vokopola, Hilmi Halimi, Esat Malasi, Jan Safanda, Milan Kresl, Lenka Kucerova, Peter Stulc.

- Outlook on the application of geophysical methods for exploration of copper and chrome ore in Albania. Tirana, 2006. Autor A. Frasheri. Në Internet.

Kontigjenti i këtyre teksteve, përgjithësisht është mbaruar dhe kane mbetur disa ekzemplarë vetëm në biblioteka.

Aktualisht, për fat të keq, studentët e degës së gjeofizikës kanë në dispozicion një literaturë në gjuhën shqipe që nuk i përgjigjet nivelit të gjeofizikës dhe të teknologjisë së vrojtimeve gjeofizike në botë.
Në bibliotekën e Fakultetit dhe atë Kombëtare nuk ka asnjë libër të ri për gjeofizikën, të botuar dhjetëvjecarin e fundit. Nuk gjendet as periodiku kryesor shkencor i huaj.

Pjesa e trete

PERFUNDIME

Për zhvillimin e gjeofizkës në Shqipëri

1. Gjeofizika në Shqipëri është zhvilluar me të gjitha metodat e saj dhe është arritur një nivel tekniko-shkencor i mirë në fushat e ndryshme të zbatimit të saj. Gjeofizika, si pjesë e rëndësishme e kompleksit gjeologo-gjeofizik-gjeokimik, ka dhënë kontributin e vet të çmuar për kërkimin dhe zbulimin e dhjetra vendburimeve të naftës e gazit, të bakrit etj. Këto arritje janë një bazë nisje e shëndoshë për të përballuar sfidat e të ardhmes, në kushtet e ekonomisë së tregut.

2. Janë përgatitur 267 inxhinjerë gjeofizikë dhe janë specializuar me kurse një vjeçare pasuniversitare në gjeofizikë dhjetra fizikanë, duke kualifikuar 45 doktorë shkencash. Ky ekip madhor ka realizuar me cilësi të lartë dhe përgjegjëshmëri detyrat që shtroi para tyre ekonomia shqiptare. Arritjet e tyre janë të mirënjohura edhe në nivel ndërkombëtar, nëpërmjet botimeve dhe referimeve.

3. Aktualisht, kërkimet dhe vrojtimet gjeofizike të naftës e të gazit, të bakrit dhe të kromit, si edhe të mineraleve të dobishme të tjera janë praktikisht të ndërprera. Dhjetra ingjinjerë e doktorë shkencash kanë emigruar jashtë shtetit. Ndërprerja e punimeve dhe studimeve gjeofizike konvencionale sjell pasoja jashtëzakonisht të rënda për kërkimet gjeologjike në të ardhmen: **U hiqen këtyre kërkimeve metodat dhe teknologjitë bashkëkohore dhe i kthejnë këto kërkime në nivelin e viteve tridhjetë të shekullit të kaluar**. Me ndërprerjen e kërkimeve gjeofizike shkatërrohen ekipet dhe humbet një përvoje gjysmëshekullore e tyre, e mirënjohur edhe nga institucione prestigjioze të vendeve të përparuara.

4. Pesëmbëdhjetë vitet e fundit përfaqësojnë edhe periudhen e zgjerimit të fushave të zbatimit të metodave gjeofizike për zgjidhjen e detyrave gjeoteknike, në studime të gjeomjedisit dhe të impakteve mbi të, në studimin e rrezikut gjeologjik, në veçanti të rrezikut dhe riskut sizmik, për kërkimet hidrogjeologjike, në studimin dhe vlerësimin e energjisë gjeotermale, etj.

5. Për zhvillimin e studimeve inxhinjerike dhe mjedisore janë shfrytëzuar të njëjtat metoda dhe teknologji që janë përdorur edhe për kërkimin e mineraleve. Aktualisht, gjeofizika inxhinjerike dhe mjedisore (me përjashtime të vogla kur është punuar në kuadrin e

projekteve europiane) punon me teknologjitë dhe aparaturat e viteve tetëdhjetë. Ekipet gjeofizike shqiptare nuk kane as kualifikimin e nevojshëm për metodat bashkëkohore, as edhe paisjet dhe aparaturat moderne për zgjidhjen e këtyre detyrave të reja gjeologjike, që shtron ekonomia e tregut.

6. Sot, në Shqipëri është e rëndësishme që, krahas kërkimeve e studimeve tradicionale gjeologjike-gjeofizike, drejtimet e reja të zbatimit të gjeofizikës në pajtim me kërkesat e ekonomisë së tregut, për zgjidhjen e detyrave inxhinjerike dhe mjedisore, duhet të realizohen duke përdorur metoda dhe teknologji moderne vrojtimi. Në të njejtën kohë, është e nevojshme që të propozohet aplikimi i teknologjive të reja për vrojtimet gjeofizike të thellësive të vogla për zgjidhjen e detyrave gjeoteknike, të kontrolleve mjedisore, të vlerësimit të impakteve mjedisore, të planifikimit urban, të kërkimeve të ujit, të kërkimeve arkeologjike, etj. siç janë tomografia sizmike e gjeoelektrike, gjeoradarët, vrojtimet e rezonancës magnetike për kërkimin e ujit, mikrorilevimet gravimetrike e magnetometrike. Studimet gjeofizike krahinore, edhe të thellësive të mëdha do të krijojnë bazën e të dhënave moderne për zbatimin e metodave analitike dhe përgjithësuese të reja për të njohur në thellësi ndërtimin gjeoelogjik të Albanideve në thellësi, që do të lejojë të orientohet më mirë vlerësimi prognozë dhe kërkimi i burimeve minerale, si edhe dinamikës së zhvillimit të rrezikut gjeologjik.

Pë formimin e specialisteve të rinj gjeofizikanë

Reforma në arsimin e lartë në kuadrin e Protokollit të Bolonjës edhe për studentët e gjeofizikës solli ndryshime thelbësore:

a) Përgatitja e specialistëve u nda në dy nivele, megjithëse të lidhura e në vijim të njëra tjetrës: diplomën bachelor-it dhe diplomën e masterit në shkencë, duke eliminuar në fakt përgatitjen inxhinjerike dhe diplomën e inxhinjerit. Për të patur sukses kjo reformë është e domosdoshme që niveli i përgatitjes së studentëve, veçanërisht në tre vitet e para, të jetë i lartë, për të përballuar mësimin e disiplinave në dy vitet e përgatitjes së masterit, kërkimin shkencor, si edhe për të kompensuar në masë të përshtatshme mungësën e të gjitha njohurive të nevojshme për inxhinjerin, sidomos ato për të projektuar dhe drejtuar teknologjitë në terren.

b) Plani i ri mësimor i Fakultetit të Gjeologjisë për specilitetin e Gjeologjisë u jep studentëve një nivel dijesh të lëndëve teorike bazë më

të ngushtë sesa për shkencat gjeologjike në krahasim me universitete europiane.

Arritjet e teknologjive moderne gjeofizike këta dhjetë-pesëmbëdhjetë vitet e fundit në botë, kanë nxjerrë jashtë pune edhe softwar-in gjeofizik, të hartuar nga katedra në vitet tetëdhjetë. Sot kërkohet rindërtimi dhe plotësimi i saj me programet që njohin kompjuterat aktualë dhe metodikat që përdor gjeofizika për përpunimin dhe interpretimin e informacionit gjeofizik. Njëkohësisht, shtrohet edhe detyra e blerjeve të softeve të specializuar.

Aparatura e laboratorit të gjeofizikës është në përgjithësi e amortizuar moralisht dhe fizikisht. Ajo nuk i përgjigjet nivelit të aparaturave që përdor sot gjeofizika. Kjo kufizon punët laboratorike që zhvillohen vetëm për disa lëndë të specialitetit, të orientuara kryesisht për demonstrime të dukurive gjeofizike të ndryshme. Megjithatë, duhet thënë se kohët e fundit është bë rë një punë e mirë në mirëmbajtjen dhe riparimin e një pjese të mirë të aparaturave si dhe janë shtuar privatisht disa aparatura e programe bashkëkohore.

Aktualisht, për fat të keq, studentët e degës së gjeofizikës kanë në dispozicion, vetëm në bibliotekë, një literaturë në gjuhën shqipe të viteve shtatëdhjetë-tetëdhjetë, e cila nuk i përgjigjet nivelit të gjeofizikës dhe të teknologjisë së vrojtimeve gjeofizike të sotme. Në bibliotekën e Fakultetit dhe atë Kombëtare nuk ka asnjë libër të ri për gjeofizikën, të botuar dhjetëvjeçarin e fundit. Nuk gjendet as periodiku kryesor shkencor i huaj. Megjithatë, privatisht, në Seksionin e Gjeofizikes dhe pjesërisht edhe në bibliotekën e Fakultetit është siguruar periodiku kryesor ndërkombëtar (Geophysics, Geophysical Prospecting, Leading Edge dhe First Break) dhe disa libra bashkëkohore. Mbetet problem njohja e gjuhës angleze në nivele të kënaqshëm nga ana e studenteve dhe disa pedagogëve.

Pjesa e kater

REKOMANDIME

Zhvillimi i gjeofizikës, që kushtëzon edhe kërkesat ndaj përgatitjes së specialistëve të rinj, për të përballuar sfidat e të ardhmes në kushtet e ekonomisë së tregut, bën të domosdoshme reformimin edhe të gjeofizikës në disa drejtime:

1. Ngritja e nivelit të kurrikulave dhe mësimdhënies, të bazës laboratorike, të teknikës përpunuese e interpretuese, të paisjes së studentave me libra të reja në gjuhën shqip, si dhe rritja e praktikave mësimore në terren për formimin e studentëve të gjeofizikës në përputhje me kërkesat e Protokollit të Bolonjës.

2. Krijimi i kushteve dhe nxitja për privatizimin e shërbimeve gjeofizike: për kërkimin e mineraleve të dobishme, për kërkimin e ujit, zgjidhjen e detyrave gjeoteknike në ndërtimin e godinave, të rrugëve, studimin e mjedisit, etj;

3. Organizmi i kërkimit shkencor, që ti përgjigjet kërkesave për eksperimentimin dhe zbatimin e metodave të reja komplekse, si edhe zgjerimin e fushave të zbatimit të gjeofizikës, të përqëndruar në universitet dhe në institucione shkencore jashtë tij, publike apo private;

4. Paisja e ekipeve gjeofizike me teknikën dhe programet e ditëve tona, që të lejojnë mundësinë e zbatimit të metodave të reja dhe përmirësimit të teknologjive të atyre ekzistuese, si për vrojtimet në terren ashtu edhe për përpunimin dhe interpretimin e rezultateve të vrojtimit;

5. Përgatija e projekteve në kuadrin e programeve të ndryshme të Komunitetit Europian, veçanërisht për fushën e studimeve krahinore të Albanideve nën shembullin e projektit europian “Crosta Profonda” (CROP), të vlerësimit të rreziqeve gjeologjike, në gjeoteknikë, të kërkimit të ujërave, të energjive të rinovueshme, etj.

6. Futja e literaturës gjeofizike bashkëkohore në bibliotekën e fakultetit dhe ngritja e nivelit të mësimit të gjuhë angleze për studentët dhe pedagoget e rinj.

7. Pas eksperimentimit të planit të ri mësimor gjatë vitit akademik 2005-2006 është e domosdoshme të bëhen rregullimet dhe axhustimet e nevojshme.

8. Çështje madhore për strukturën e re akademike, e cila nuk duhet të mbesë e pa diskutuar dhe në hije është diploma e masterit, me të cilën emërtohen studentët e aftë për veprimtari kërkimore-shkencore, të cilët më von duhet të kalojnë edhe nëpër përgatitjen e doktoratës së shkencës. Kjo kërkon që nga studentët e tre viteve të para të arrihen rezultate të mira dhe shumë të mira në përvehtësimin e dijeve. Studentët e nivelit 5-7 nuk e kanë bazën e njohurive të dëmshme për të ndërtuar godinën e kualifikimit për kërkimin shkencor. Diplomimi i tyre "Mjeshtër në shkencë" është në kundërshtim edhe me Rregulloren shqiptare për kualifikimin pasuniversitar SHPU, prandaj diplomimi i tyre mbetet një diplomë fiktive për ta dhe e dëmshme për shoqërinë. Kjo u duhet bërë e ditur si studentëve ashtu edhe prindërve, të gjithë opinionit shqopëror të vendit. Prandaj duhet diskutuar emërtimi i diplomës pas pesë viteve të studimit universitar. Një variant i mundshëm mund të jetë:

- Diploma "Mjeshtër në shkencë" për studentët me mesatare 8 e lart,

- Diploma "Gjeofizik", "Gjeolog" etj. për studentët me mesatare nën tetë, si në shumë universitete europiane.

SEG Annual Meeting and International Showcase.

GLOBAL TEATER

17–22 October 2010 - Denver, Colorado USA

"Bologna" Model and Geophysical Formation in the Faculty of Geology and Mining

Alfred FRASHERI*, Salvatore BUSHATI**

***Faculty of Geology and Mining**

**** Academy of Sciences of Albania**

Tirana, October 2010

The work done in the development process of geophysics in Albania by the academic staff of the Section of Geophysics in the Department of Earth Sciences, Faculty of Geology and Mining, Polytechnic University of Tirana was of a great impact. Two were the main directions in which the attention of this academic staff was paid:

- engineers education process, their postgraduate qualification, and

- scientific research.

Since 1961, the education process of the engineers of this field and their postgraduate training was realized in the Branch of Geophysics, Section of Geophysics in Department of Earth Sciences, Faculty of Geology and Mining, Polytechnic University of Tirana.

The period of studies comprised **5 academic years** for **engineers,**

1-2 years for **postgraduate qualifications (Master)**, and

3 years for **doctoral studies**.

...

Current main courses for applied geophysicist engineers are:

- Exploration of oil and gas reservoirs,
- Exploration solid minerals deposits,
- Hydrogeological research and,
- Engineering and environmental studies.

The period covering the years 1961-2008 marked the compilation process and the continuous improvement of curricula in line with:

- scientific level and
- current situation of technological research and geophysical studies and exploration.

...

In the Framework of Bologna Protocol implementation, the Branch of Geophysics was closed.

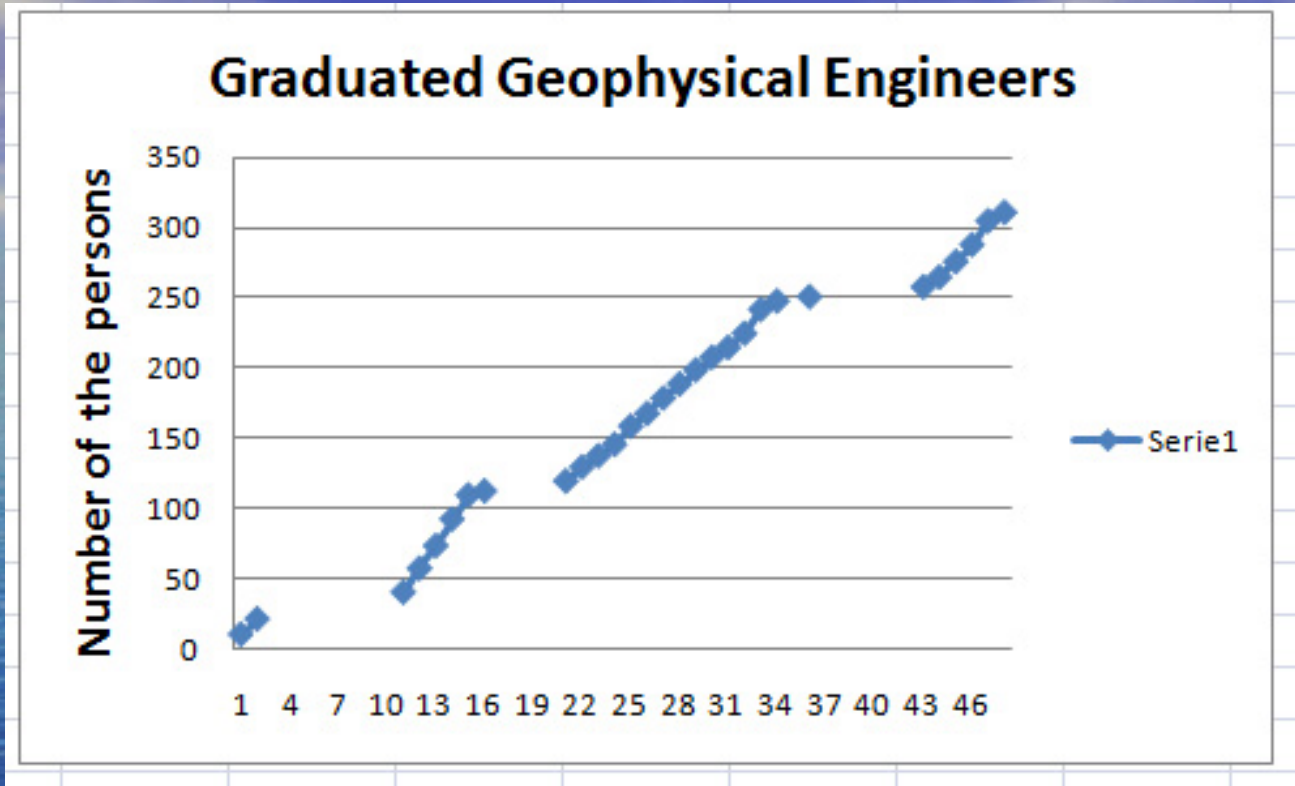
Under the new curricula:

- after **Diploma Bachelor** for Georesources and Geoinformatics – **3 years** of common cycle,

- **Scientific Master degree in Geophysics**, through option in the second year of the second cycle.

With this curricula, as have been prepared in implementation of Bologna Protocol, results level landing of the scientific and professional formation of geophysical engineer.

- **CONTRIBUTION OF THE FACULTY OF MINING IN THE DEVELOPMENT PROCESS OF GEOPHYSICS IN ALBANIA**



GRADUATED PERSONS

Engineer Geophysicists 304

Dr. Sc. 45 Research Leaders 9

Professors 7 Prof. Ass. 1 Masters Research 12

Geophysics Disciplines

	1961-1964	1973-1978	2002-2005
Magnetic surveys	+	+	+
Gravity surveys	+	+	
Geoelectrical Exploration	+	+	+
Waves theory-seismics	+	+	+
Wave theory- seismics-seismology			+
Stratigraphic seismics			+
Engineering seismics			+
Well logging	+	+	+
Radiometry	+	+	+
Signal processing			+
Physics of the Earth		+	+
Data processing and interpretation		+	+
Engineering geophysics			+
Environmental geophysics			+
Mining Geophysics			+
Geothermics			+

Mathematical Disciplines

	1961-1964	1973-1978	2002-2005
Mathematic Analyzes	+	+	+
Analytic Geometry	+	+	+
Special Fis. Math. Equations and special functions	+	+	+
Linear Algebra		+	+
Statistics and Probability		+	+
Geostatistics			+
Informatics Programing		+	+
Numerical Analyzes		+	+

Geological Disciplines 3- 5 academic years

- Paleontology & Stratigraphy
- Mineralogy &Crystallography
- Petrography & Petrology
- Geochemistry
- Structural Geology and Mapping
- Topography
- Geology of solid minerals deposits
- Oil and gas geology
- Metallogeny
- Solid Mineral Exploration and Developing Methods
- Reservoir Geology

Geological Disciplines 3- 5th years

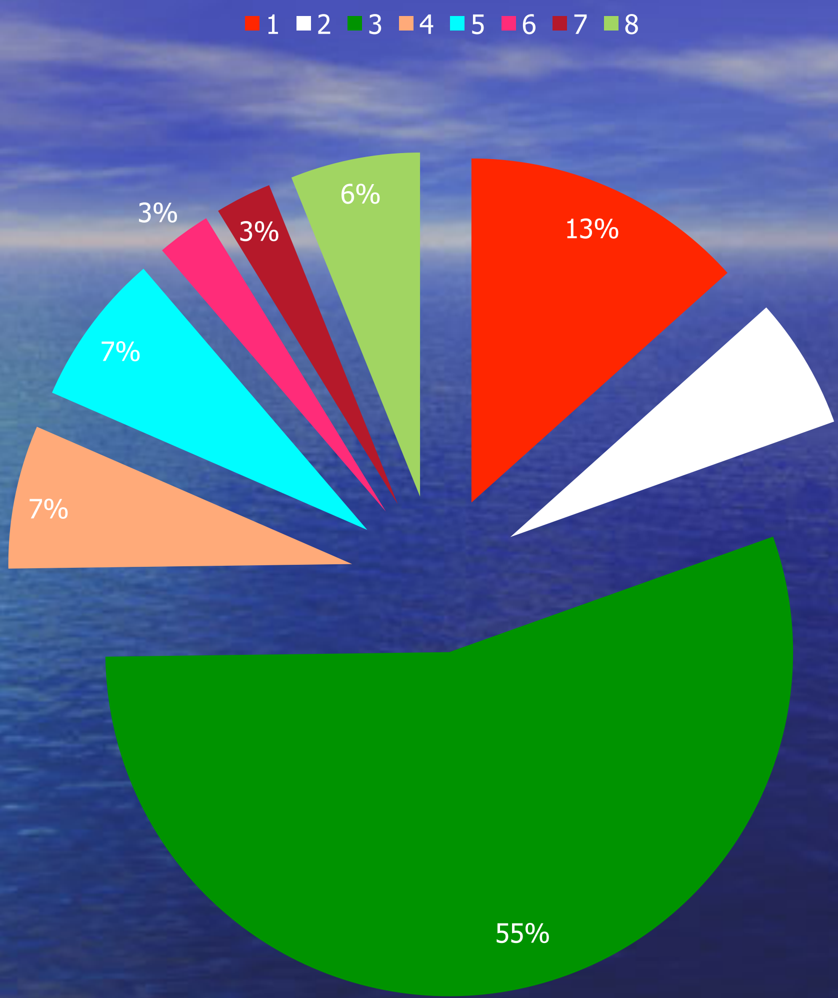
- Geodynamics
- Geology of the Albania
- Drilling
- Mining Art
- Economics and management of , geological exploration, mining and oil industry.
- Hydrogeology
- Engineering Geology
- Environmental Geology

2000-2004

Nr	Discipline	Hours	Nr	Discipline	Hours
	Social disciplines			**Geological disciplines**	
1	Sociology	45	25	General geology	75
2	Physical educate	120	26	Paleontology, stratigraphy, historical geology	60
3	Foreign language	240	27	Geomorphology and Quaternary Geology	36
	Theoretical base disciplines		28	Mineralogy, petrography	120
4	Albegra and analytic geometry	120	29	Structural geology and geotectonic	111
5	Mathematical and numerical analyziz	330	30	Geology of solid deposits and their exploration	120
6	Statistics and probability	75	31	Petroleum geology and	144
7	Special equations of the physical mathematics	70	32	Hydrogeology and engineering geology	60
10	Informatics	120		**Geophysical disciplines**	
11	Geostatistics	48	33	Gravity survey	105
12	Physcs	255	34	Magnetic survey	91
13	General and physical chemistry	120	35	Geoelectrical survey	196
14	Signal Processing	90	36	Waves theory, seismic and seismology	274
	Engineering disciplines		37	Well logging	194
15	Geodesy and markshaidery	75	18	Nuclear geophysics and radiometric survey	133
16	Descriptive geometry and technical design		19	Physic of the Earth	60
17	CAD	45	20	Market economy basis	60
18	Engineering graphics	135	19	**Otional disciplines**	70
19	Theoretical and engineering mechanics	120	20	Problems of the geophysical explorations	
21	Electrotechnique and applied electronique	90	21	Problems of the reservoir study	
22	Geoinformative systems (GIS)	60	22	Geoengineering geophysics	
23	Mining and drilling technologies		23	Undeground geophysical survey	
			24	Environmental Geophysics	
			25	Total	**4363**

BACHELOR GEOLOGICAL ENGINEERING DIPLOMA

...



1. Physical Mathematics; 2- Chemistry; 3- Geological; 4- Technical disciplines; 5- General technical disciplines; 6- Informatics;

7- Foreign Language; 8- Geophysical disciplines

EVOLUTION OF TEACHING CURRICULA FROM 1962-1988

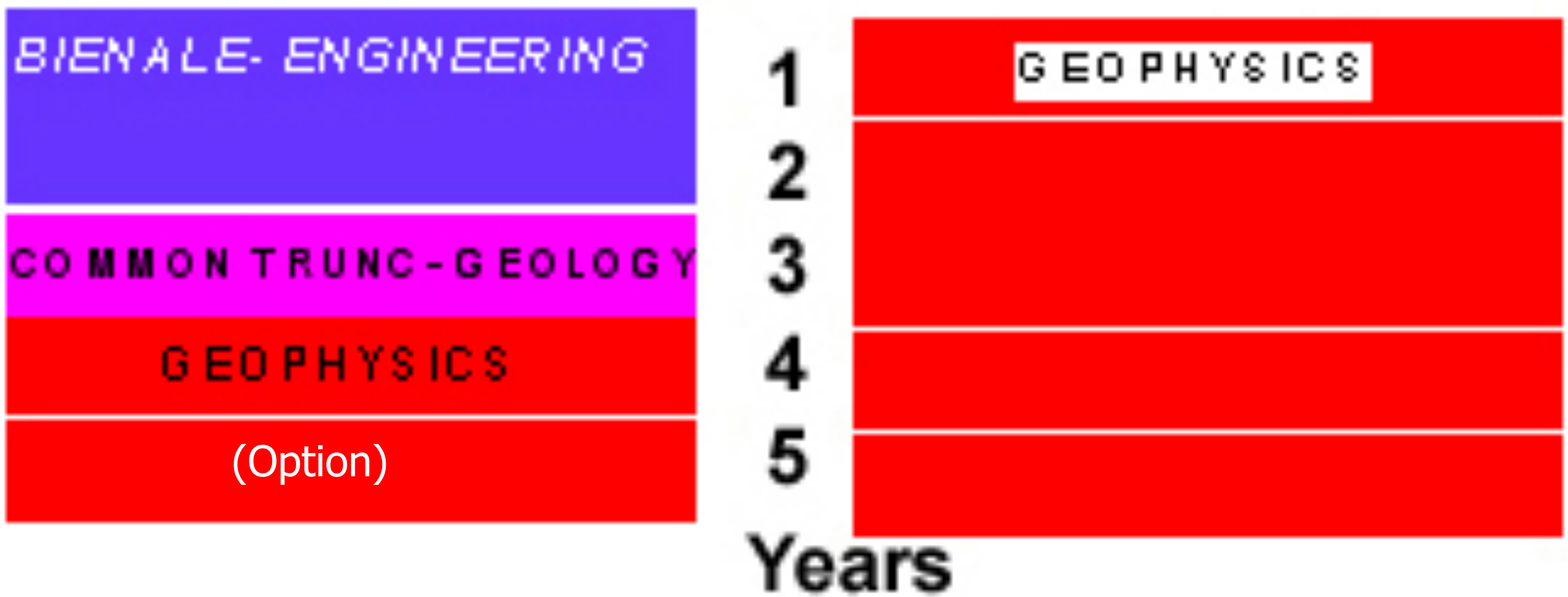
Teaching Curricula 1961-1964

Teaching Curricula 1967-1988

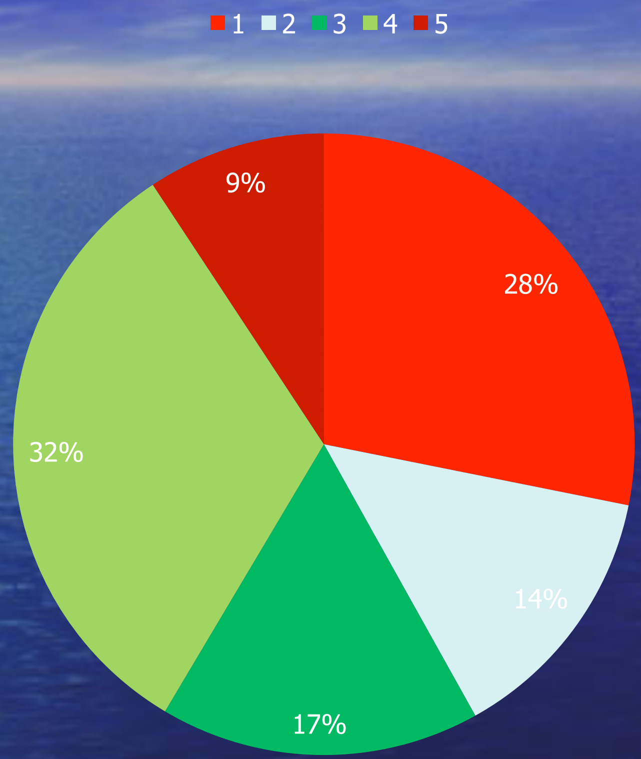
EVOLUTION OF TEACHING CURRICULA FROM 1992-2005

Teaching Curricula 1992-1996

Teaching Curricula 2002-2005

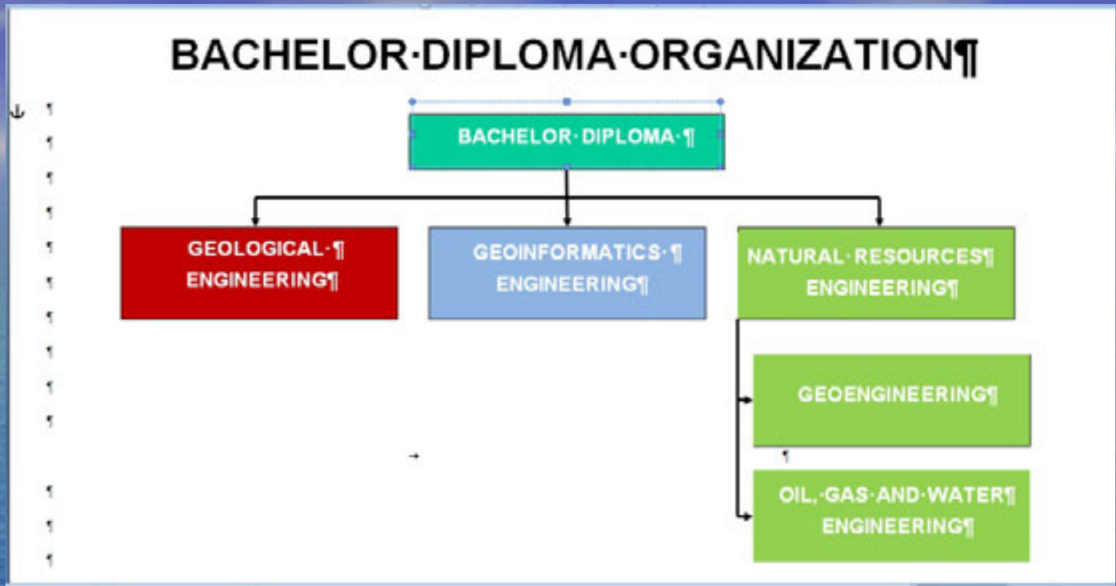


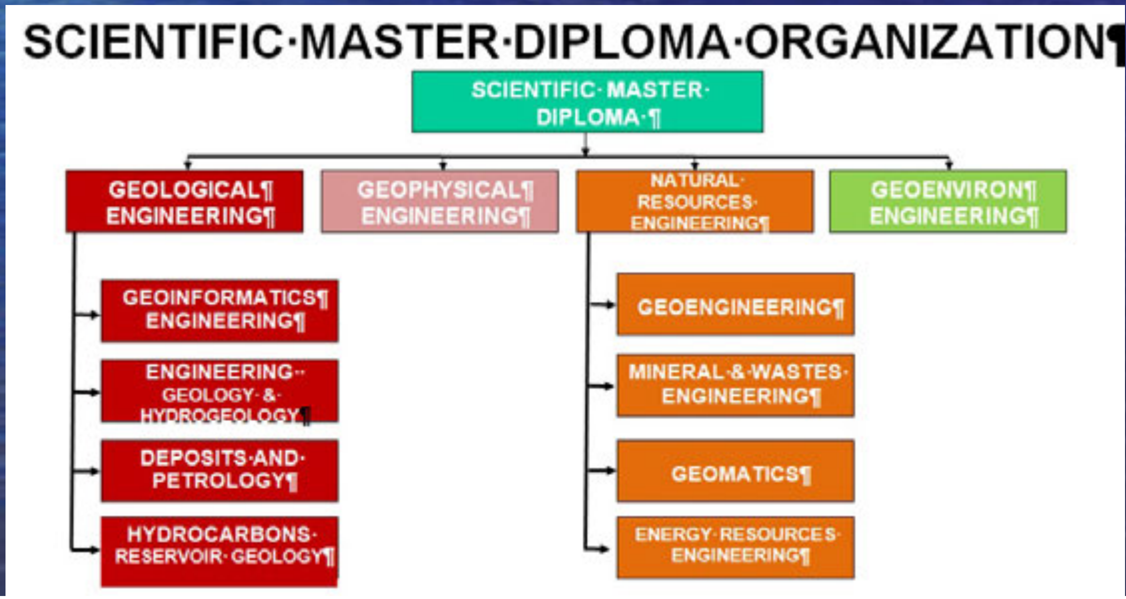
5 YEARS SYSTEM EGINNERING: **GEOPHYSICAL ENGINEER 2000-2004**



DISCIPLINES: 1. Theoretical; 2. Engineering; 3. Geological; 4. Geophysical; 5. Social

GEOPHYSICS IN THE FACULTY OF GEOLOGY AND MINING IN FRAMEWORK OF THE BOLOGNA MODEL



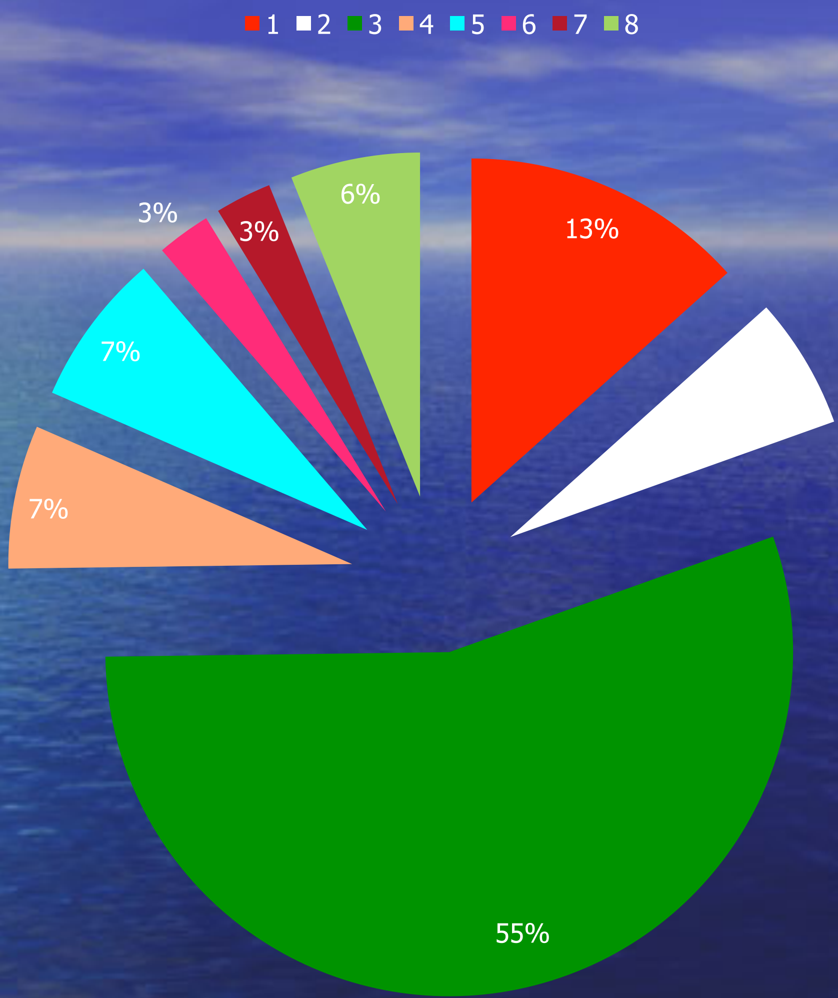


BACHELOR DIPLOMA

GEOLOGICAL ENGINEERING

I YEAR	Disciplines	ECTS	Hours
1	Chemistry 1+2	**8**	102
2	Mathematic 1+2	**8**	102
3	Technical design + CAD	**4**	43
4	Geomatic	**4.5**	54
5	Physics 1+2	**9**	114
6	General Geology	**3.5**	48,5
7	Mathematical Statistics	**5**	63
8	Informatics	**5**	63
9	Paleontology – Historical Geology	**5**	77,5
10	Chrystalographyi + Chrystalochemistry	**3**	34,5
11	Foreig Languege	**5**	66
Total		**60**	**768**
II YEAR			
12	Paleontology – Historical Geology	**5.5**	70
13	Optical Mineralogy	**4.5**	74
14	General Mineralogy + systematics + Methods	**6.5**	22
15	Petrology + Magmatic Petrography	**8.5**	155,5
16	Sendimentary ande metamorphic Petrography	**5**	82,5
17	Mechanic + Resistance of the materials	**4.5**	58
18	Sedimentology + Marine Geology	**7.5**	103,5
19	Stratigraphy	**4.5**	73,5
20	Geological Mapping	**6.5**	113
21	Structural Geology	**7**	103
Total			
III YEAR			
22	Mechanic of medium continue	**4**	52
23	Geochemistry basis + environmental geochemistry	**7**	90
24	Applied Geophysics	**10**	152
25	Techtonic	**5**	64
26	Hydrogeology	**4**	52
27	Sedimentary Basins + Hydrocarbon reservoirs	**4**	52
28	Metallic Deposits, Econimical Minerals	**6**	82,5
29	Regional Geology	**6**	78
30	Rocks and Soil Mechanics	**3**	38
31	Drilling and Mining Geotechnology	**6**	78
32	DIPLOMA	**5**	0
33	GIS and themai mapping	**6**	78
34	Environmental Geochemistry and hydrochemistry	**4**	52
Total		**60**	**739**
	TOTAL for BACHELOR DIPLOMA GEOLOGICAL ENGINEERING	**180.00**	**2321.0**

… BACHELOR GEOLOGICAL ENGINEERING DIPLOMA



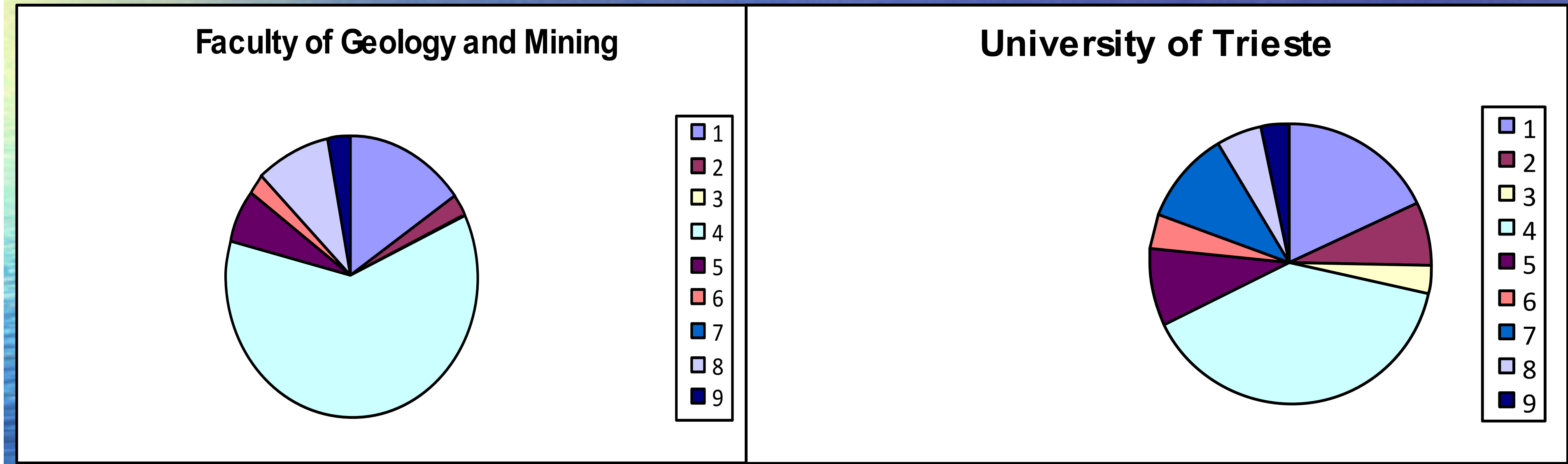
1. Physical-Mathematics-Physics; 2- Chemistry; 3- Geology; 4- Technial disciplines of the speciality; 5- General technical disciplines;

6- Informatics; 7- Foreign Language; Geophysics

SCIENTIFIC MASTER DIPLOMA
GEOLOGICAL ENGINEERING
Speciality: GEOPHYSICAL ENGINEERING

Nr.	DISCIPLINE	ETC	HOURS
I - YEAR			
1	Electrotechnic & Electronic	4	48
2	Topography & GIS	4	54,5
3	Addendum in mathematic	11	121
4	Potential fields	11	140,5
5	GeoelectricAL method	13	172
6	Theory of vawe's scattering & seismology	10	108,5
7	Seismic of reflected and refracted vawes 1	7	96
Total		**60**	**644,5**
II - YEAR			
8	Seismic of reflected and refracted vawes 2	7	96
9	Nuclear physics and radiometry	7	80,5
10	Well logging	10	98,5
11	Digital processing and stratigraphic seismic	10	108,5
12	Geology of natural reservoirs	5	54
13	Optional discipline: - Geophysics of natural resources - Engineering and Environmental Geophysics e	6	62,5
Total		**50**	**311**
	TOTAL for Scientific Master on Geophysics	**110**	**955,5**

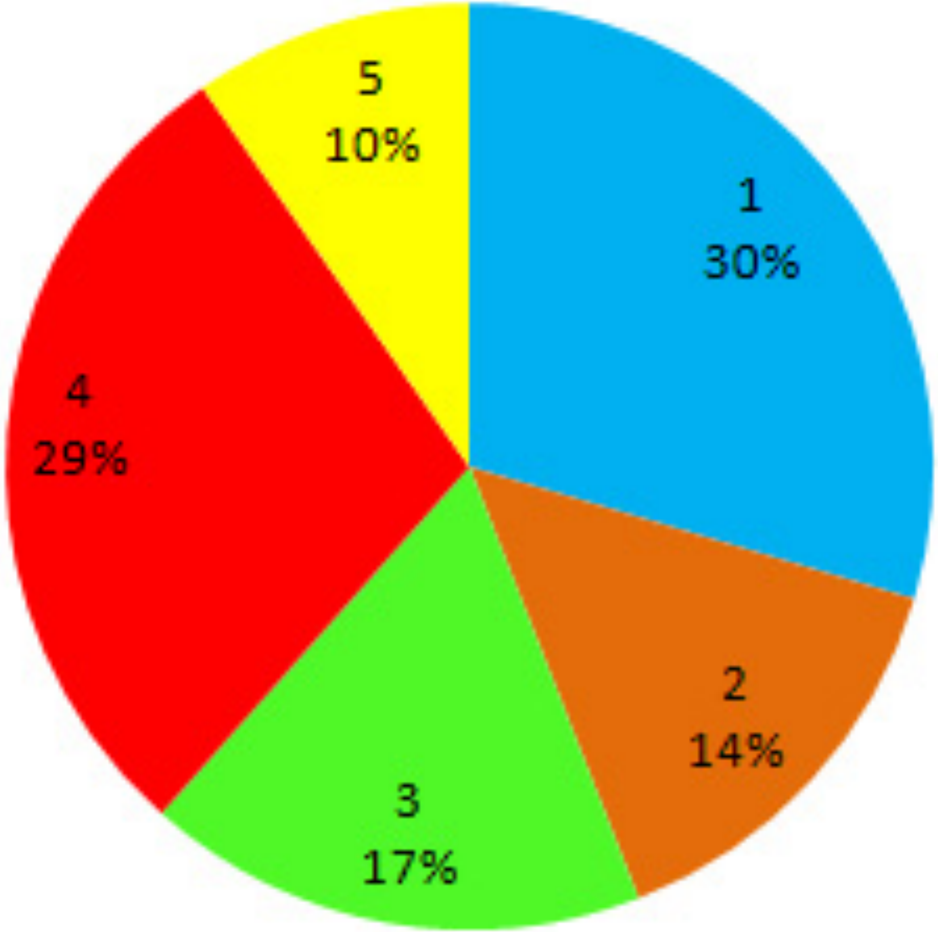
COMPARISON OF CURRICULA
EARTH SCIENCES BACHELOR DIPLOMA



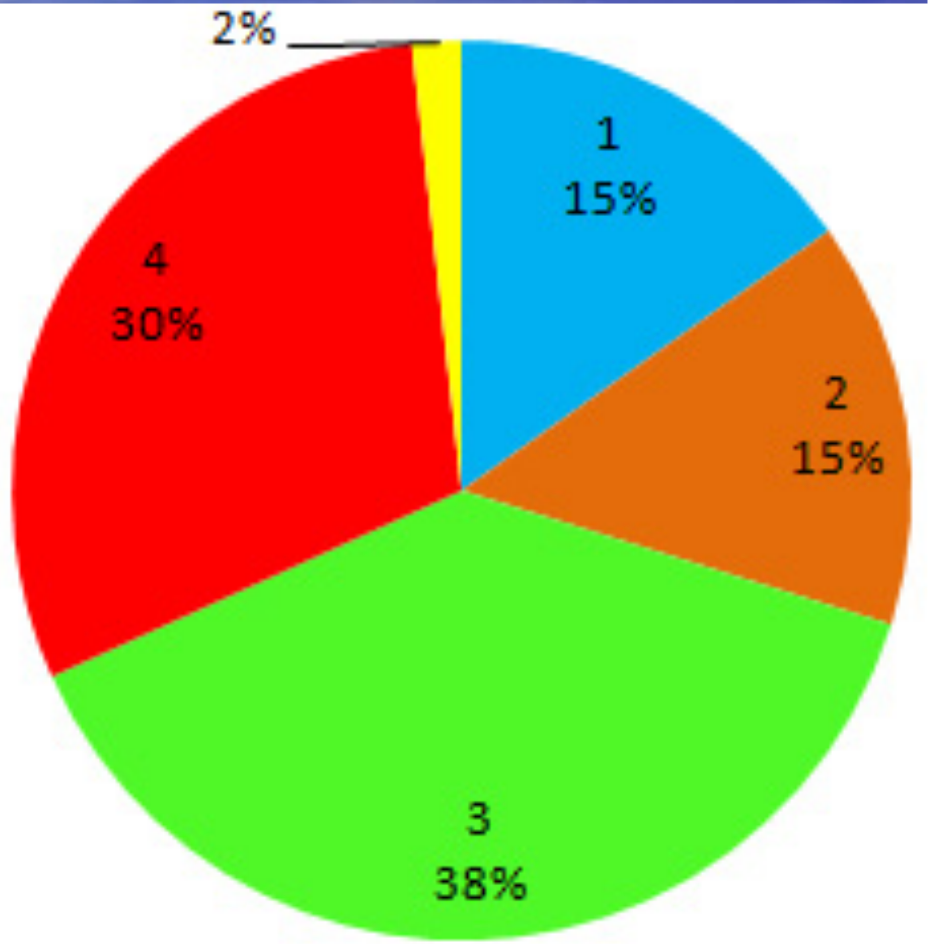
DISCIPLINES: 1- Theoretical; 2- Engineering; 3- Nature;
4- Geological; 5- Geophysical; 6- Social;
7- Indipentent work; 8-Stage; 9- Diploma

COMPARISON OF THE TEACHING CURRICULA

5 YEAR SYSTEM 2000-2004



BOLOGNA MODEL 2007-Now



DISCIPLINES: 1. THEORETICAL; 2. ENGINEERING; 3. GEOLOGICAL
4. GEOPHYSICAL; 5. SOCIAL

TEACHING STRUCTURE

Teaching process is implemented through:

- 1. Lectures,
- 2. Practical lessons:

    a) laboratory,

    b) seminars,

    c) solutions of exercises and project courses,

    d) the field.
- 3) Project diploma.

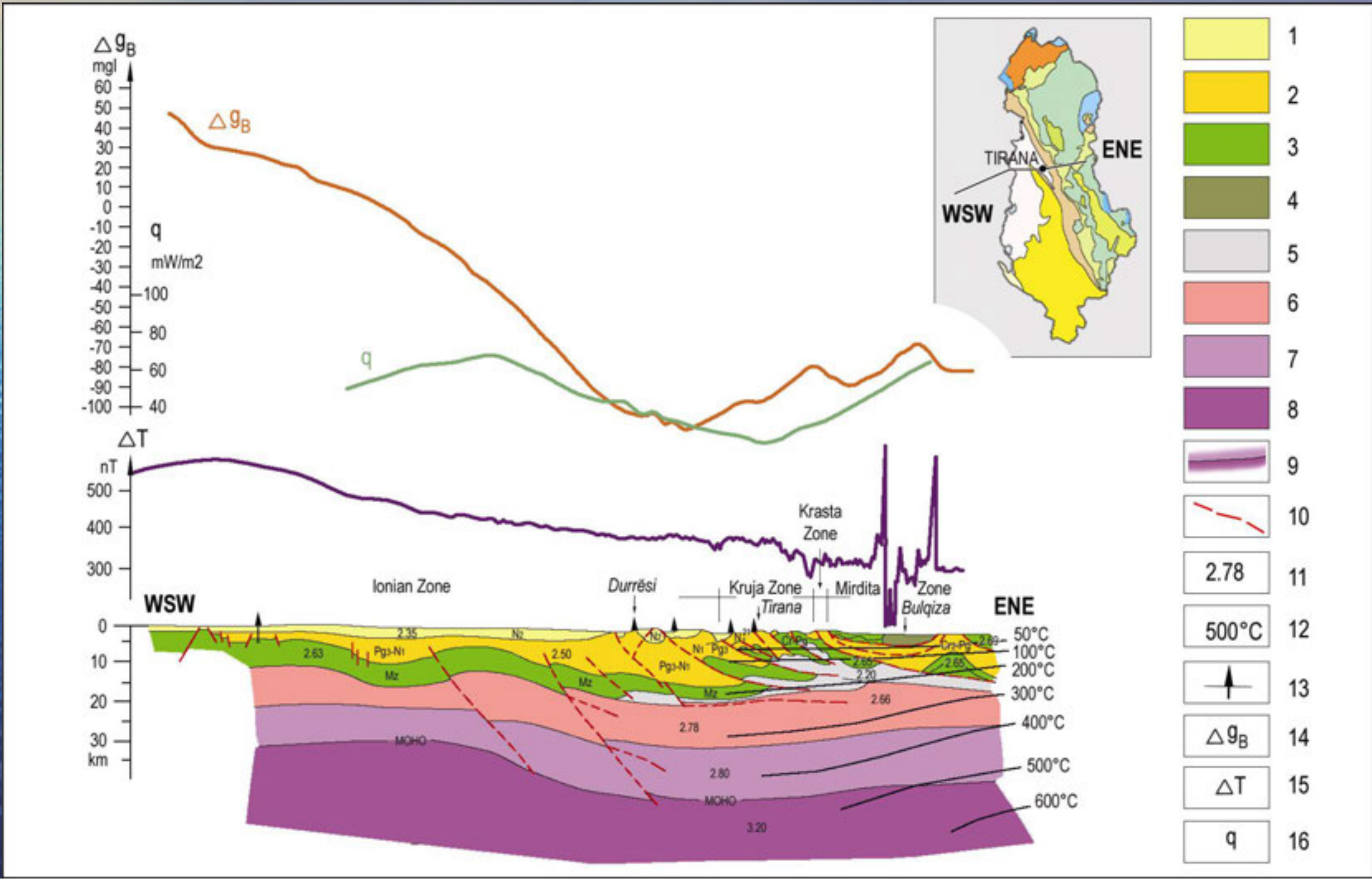
Seismic surveys practic

Scientific research activity of the professors of the Geophysics Section, in the collaboration with geophysicists of the mining and oil and gas industries, during 1961-2010 period has been oriented in following directions:

Regional Geophysics

Geophysical Regional Studies (1967-)

(L. Lubonja, A. Frasheri, S. Bushati, Nishani P., Silo V.)



Gravity and Magnetic Maps of Albania, at scale 1:200.000,

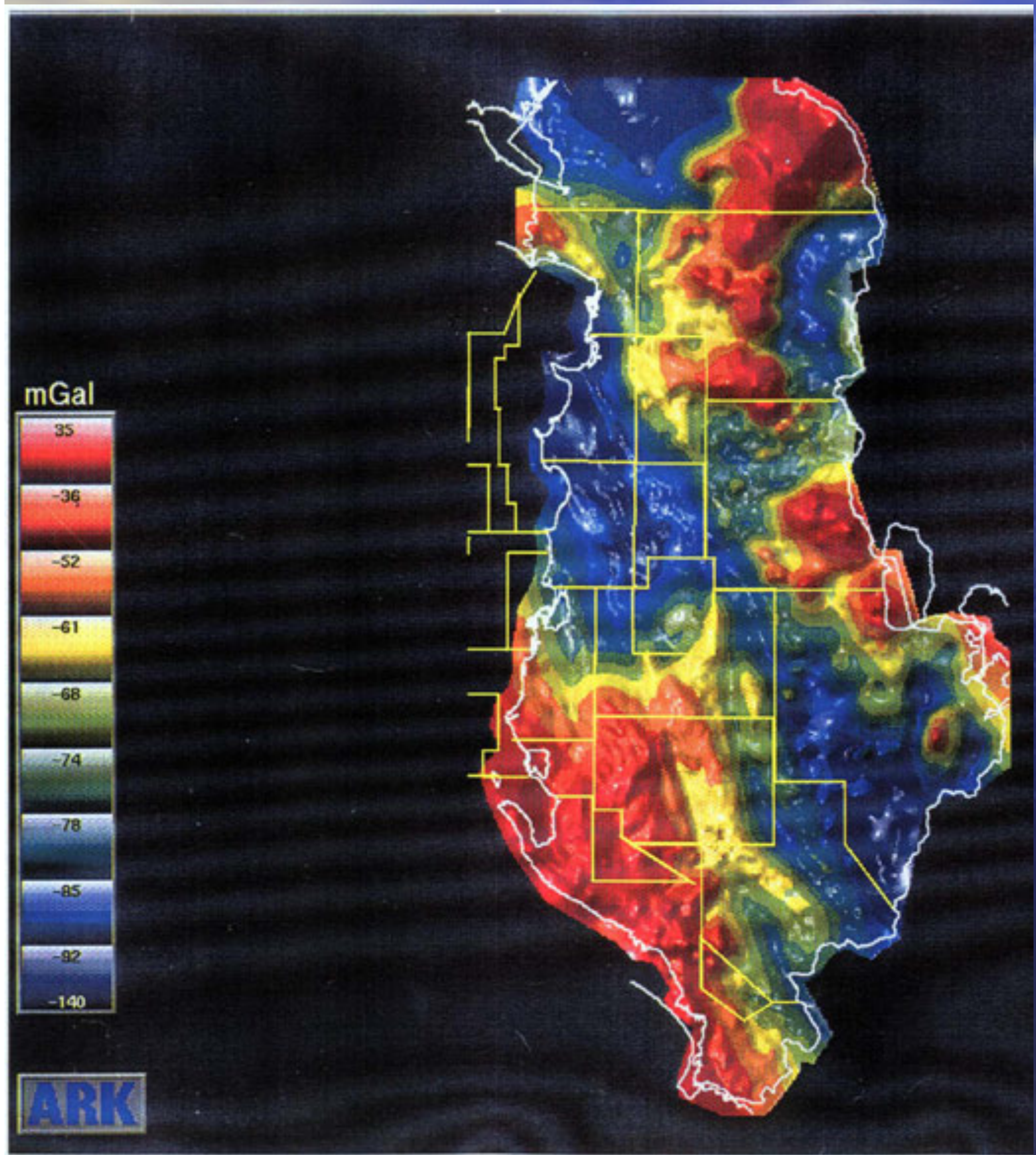
Gravity and Magnetic Network of Albania (1998)

Normal Magnetic Field and other Components of Albania (1997-)

Performed by Geophysical Center of Geological Survey of Albania. Scientific Leader: Academic Professor Dr. Salvatore Bushati.

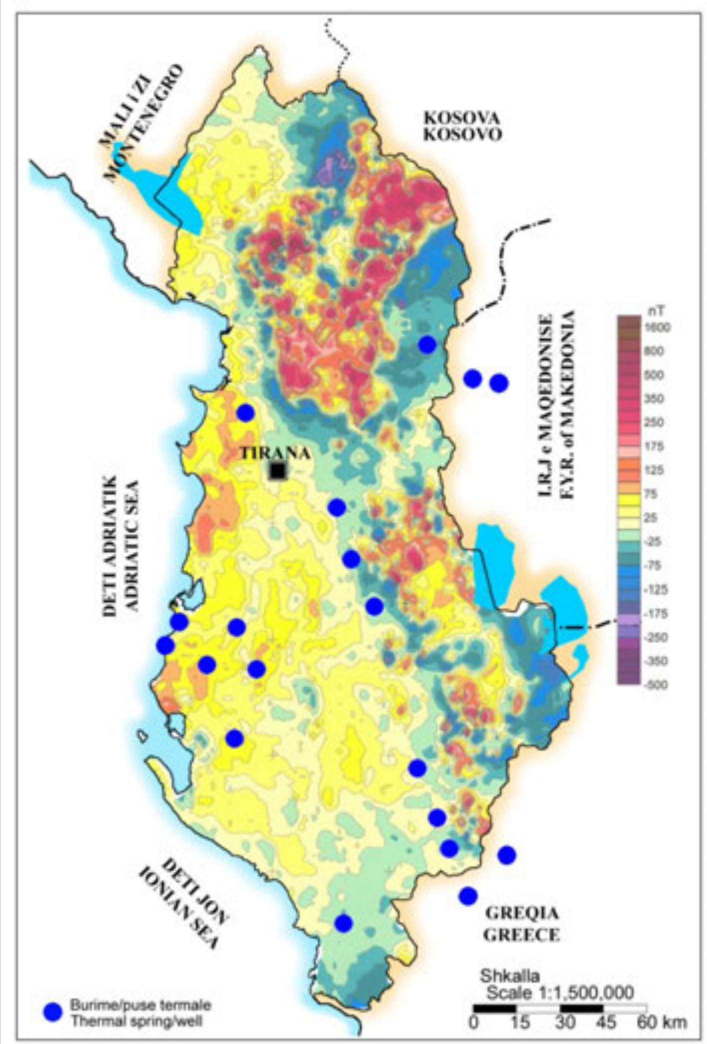
GRAVITY MAP

Bouguer Anomaly



MAGNETIC MAP

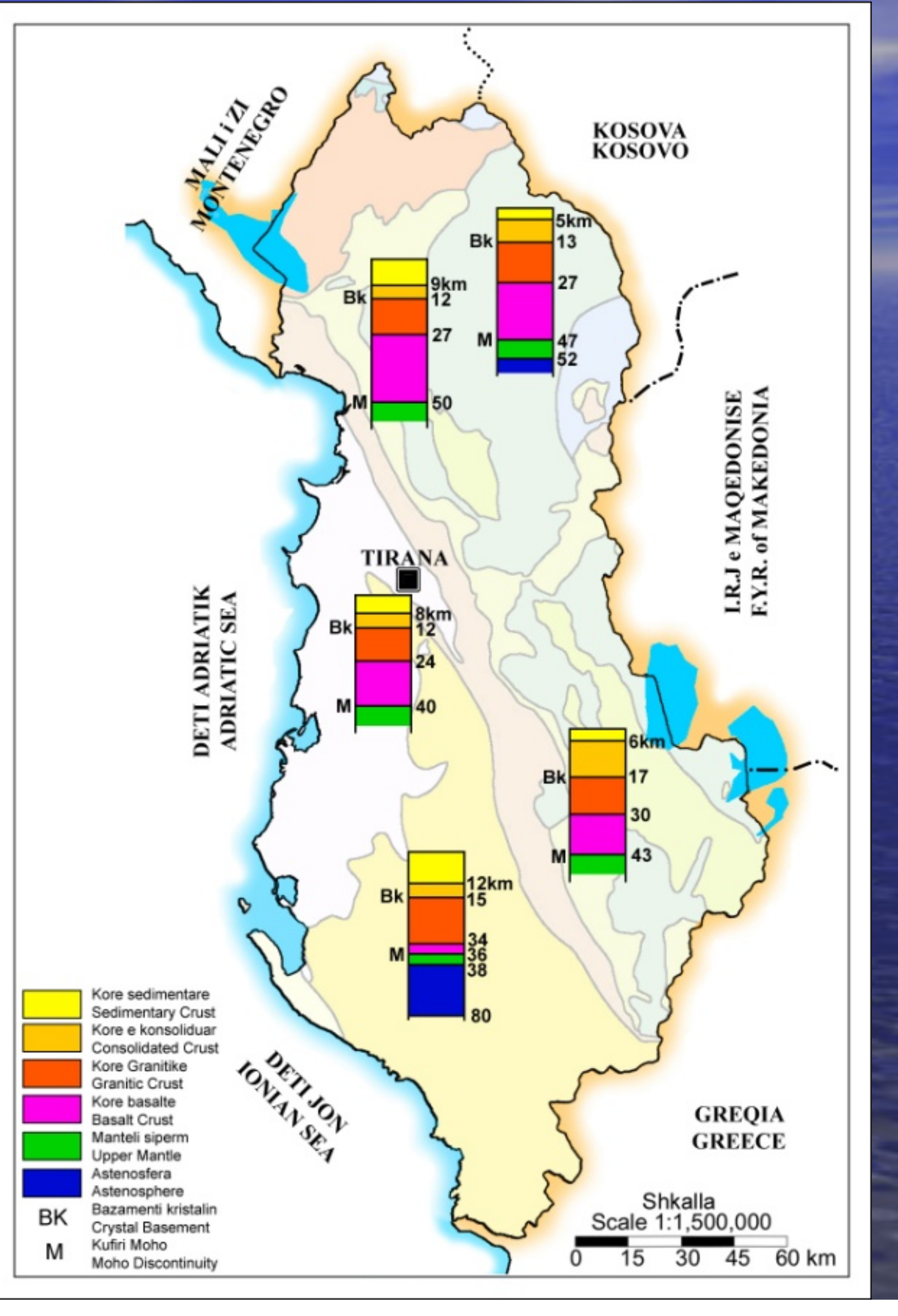
(T)



Harta e fushës magnetike totale
Total Magnetic Field Map

Fleta / Plate 3

Sesimological and Earth Crust studies Prof. Dr. Siasi Kociaj (since 1968)



...

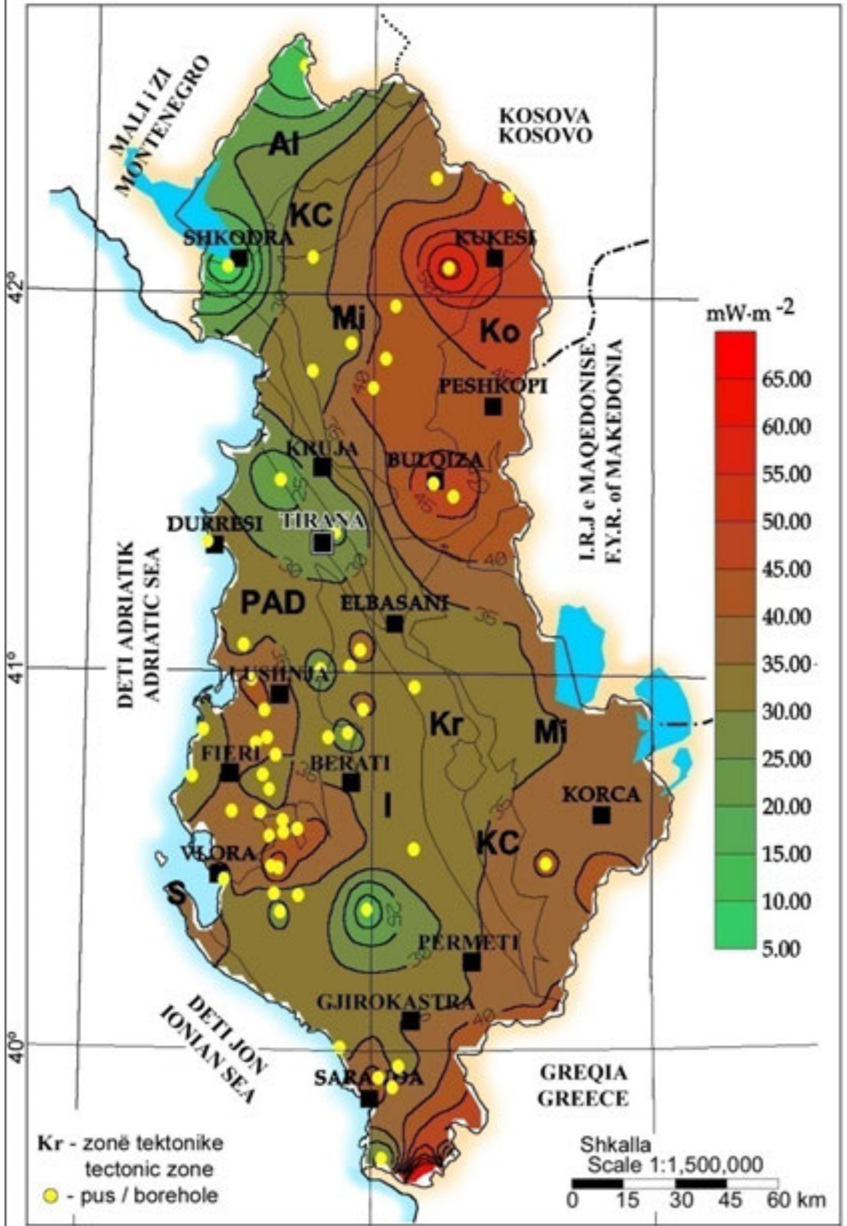
1. **Geothermal studies** (Since 1989)

Joint project: - Faculty of Geology and Mining

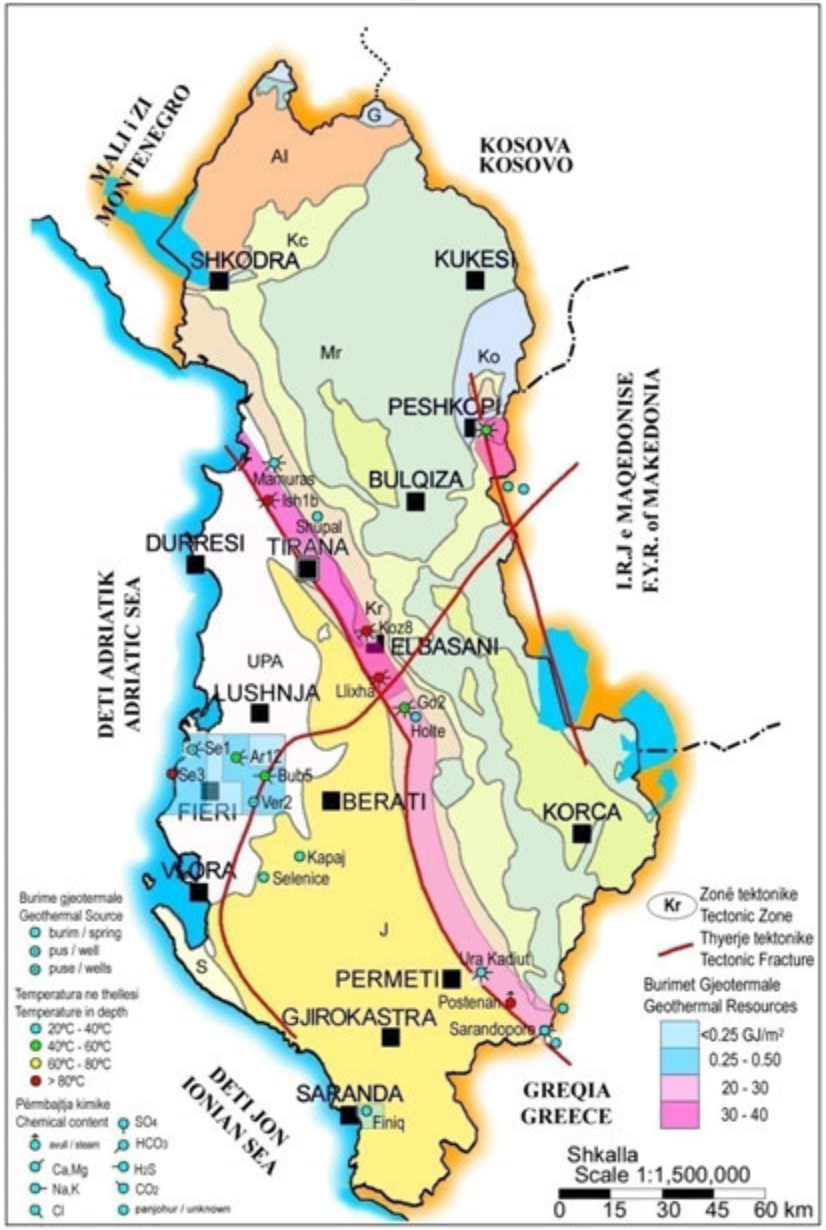
- Insitute of Geophysics, Academy of Sciences, Czech Republic, Prgue.

(Frasheri A., Cermac V., Lico R., Bushati S., et al.)

- Temperature Map of Albania at 100; 500; 1000; 2000; 3000 m depth.
- Geothermal Gradient Map of Albania.
- Heat Flow Density Map of Albania.
- Geothermal Resources Map of Albania.



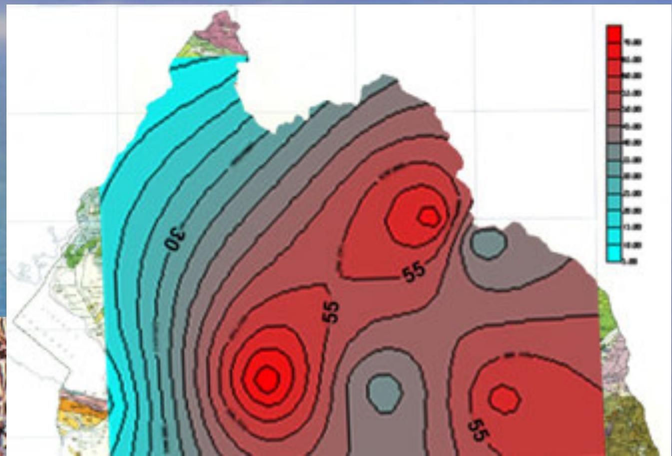
Harta e dëndësisë së fluksit të nxehtësisë
Heat Flow Density Map



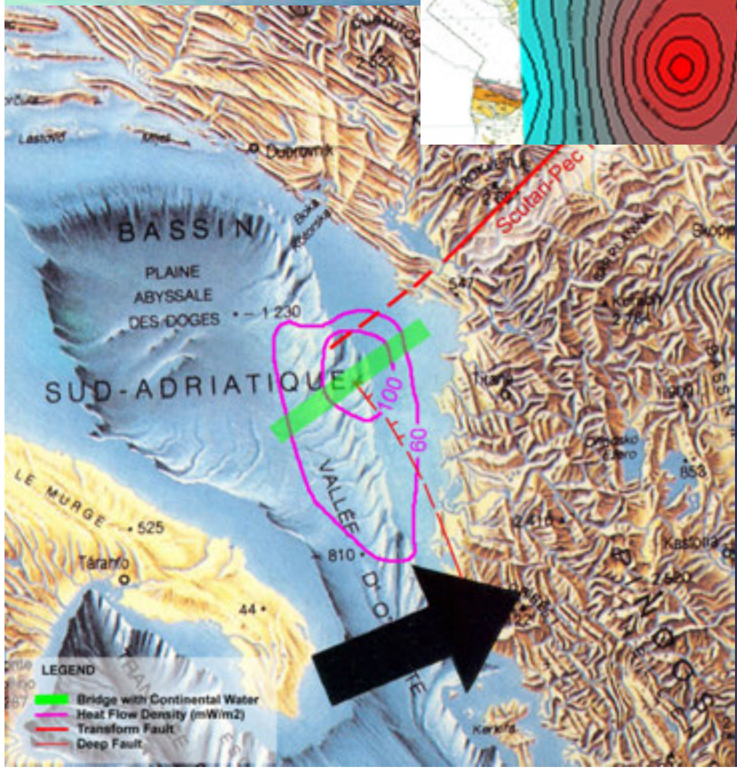
Harta tematike gjeotermale
Geothermal Thematic Map

Heat Flow Density Anomaly, Adriatic Sea

“Geothermal Atlas of Europe”



and onshore anomaly over Scutary-Pec transversal study

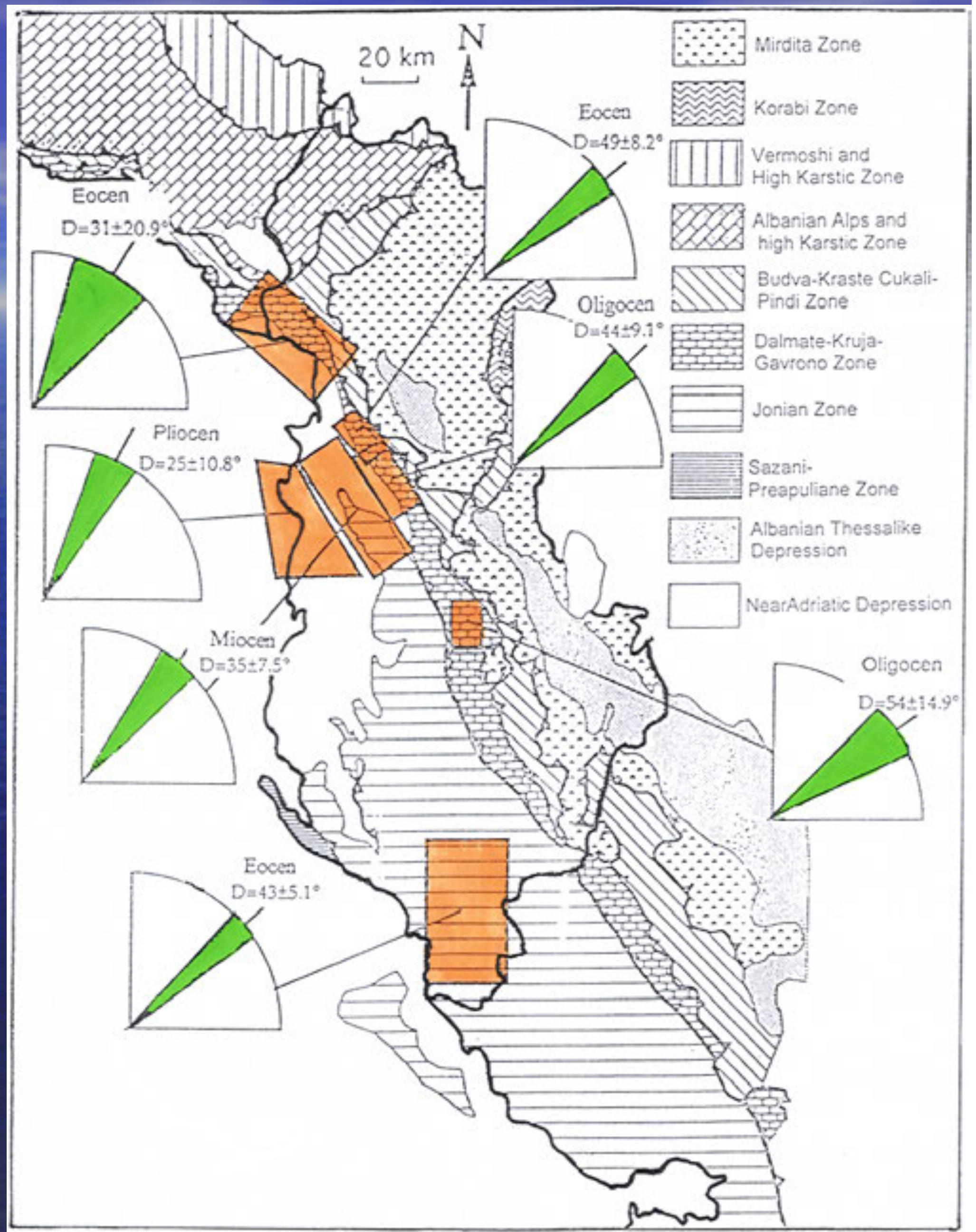


Paleomagnetic Studies

Joint Projects:

- University of Leoben
Mauritch H.J.
- Laboratoire de Paleomagnetisme, Gif sur Yvette, Paris.
Kissel C., Lai C, Speranza F
-University of Thessaloniki
Condopoulou D.

- Faculty of Geol. & Mining
S. Bushati, A. Frasheri, P. Alikaj) (1989-1997)



Mining Geophysics

(Lubonja L., Frasheri A., Avxhiu R., Alikaj P., Bushati S.)

1. Experimentation and application in Albania of new geophysical methods:

- Induced Polarization (1962-),
- Magnetic micro-survey (1967-),
- IP and RD Real Section (1978-),
- Depth Investigation Increasing of Mining Geophysics (1984-).
- Physical and Mathematical Modeling, inversion(1973-)

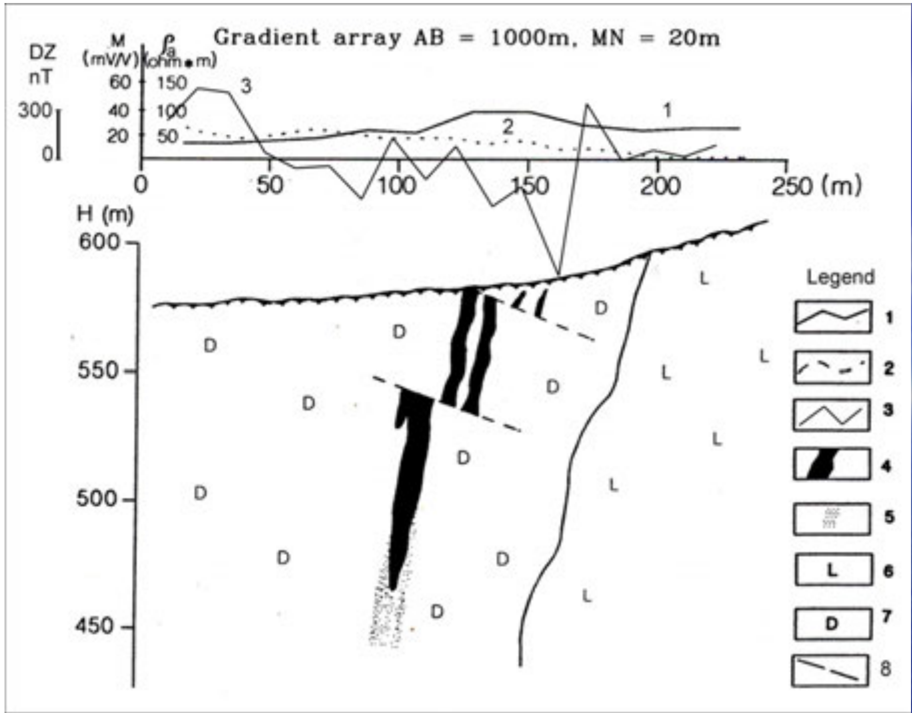
For the exploration of copper and chrome ores.

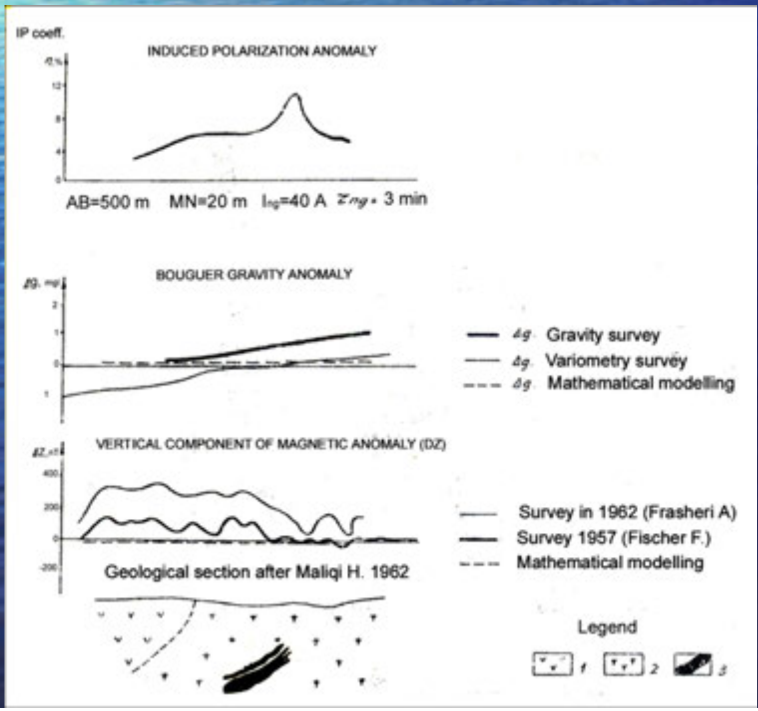
Mining Geophysics

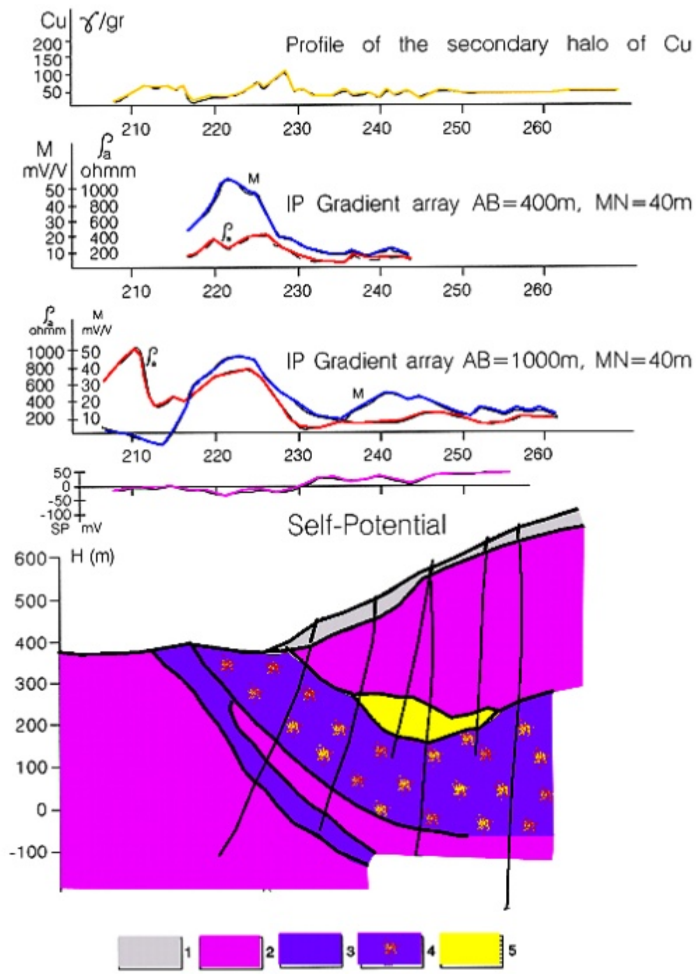
(Lubonja L., Frasheri A., Avxhiu R., Alikaj P., Bushati S.)
(1960-)

2. Extension of the application field of the geophysical methods in the search for:
   - chrome,
   - copper,
   - asbestos,
   - bauxite,
   - placer of heavy, rare and precious minerals,
   - Geotechnical and environmental engineering investigation,
   - Hydrogeological exploration,
   - Application of Self-potential method for direct exploration of oil and gas reservoirs

geophysics


Gradient array AB = 1000m, MN = 20m
DZ
nT
Legend
H (m)
250 (m)

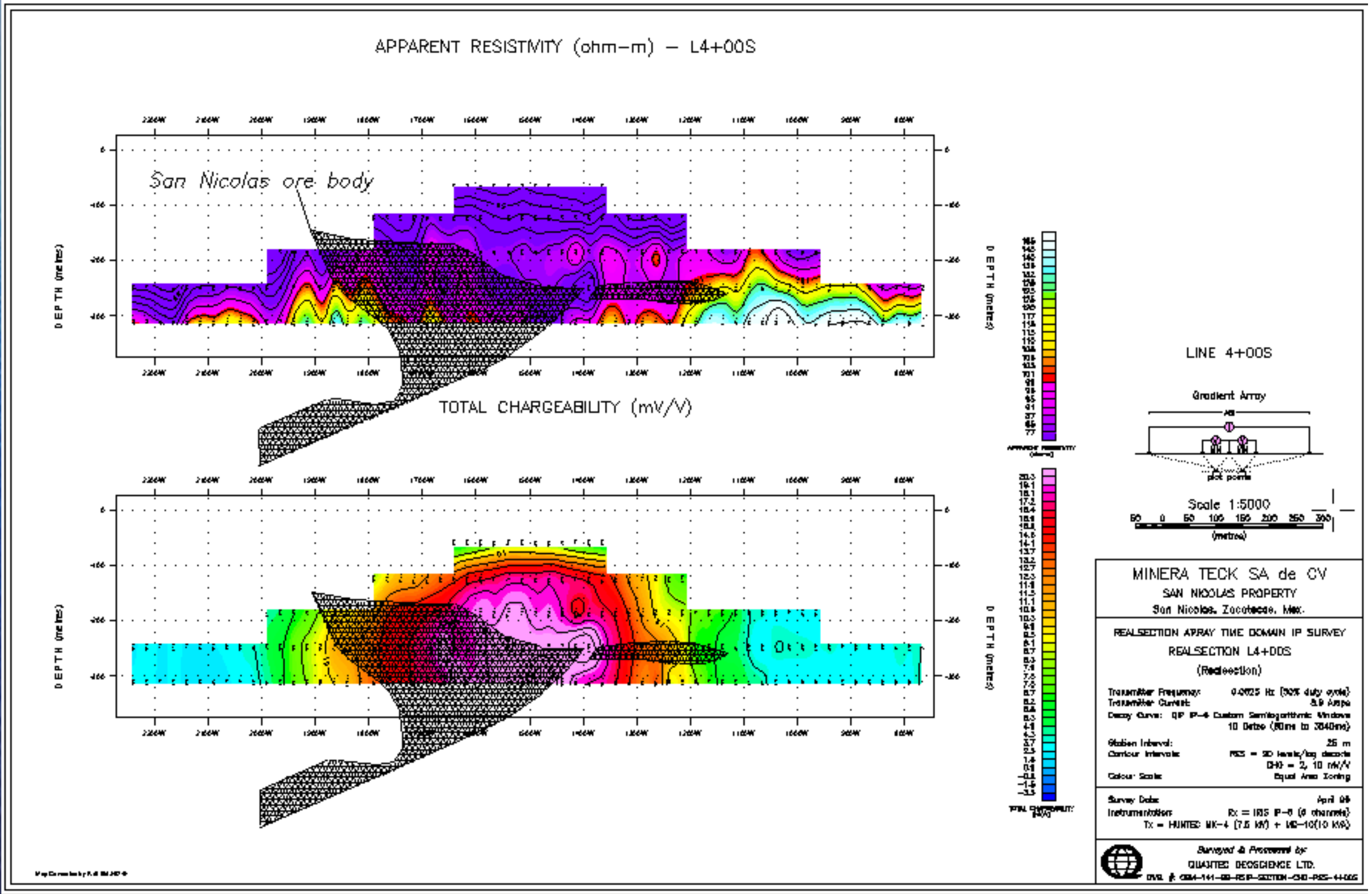

IP coeff.
INDUCED POLARIZATION ANOMALY
AB=500 m MN=20 m
BOUGUER GRAVITY ANOMALY
Gravity survey
Variometry survey
Mathematical modelling
VERTICAL COMPONENT OF MAGNETIC ANOMALY (DZ)
Survey in 1962 (Frasheri A)
Survey 1957 (Fischer F.)
Mathematical modelling
Geological section after Maliqi H. 1962
Legend


Profile of the secondary halo of Cu
IP Gradient array AB=400m, MN=40m
IP Gradient array AB=1000m, MN=40m
Self-Potential
H (m)

…

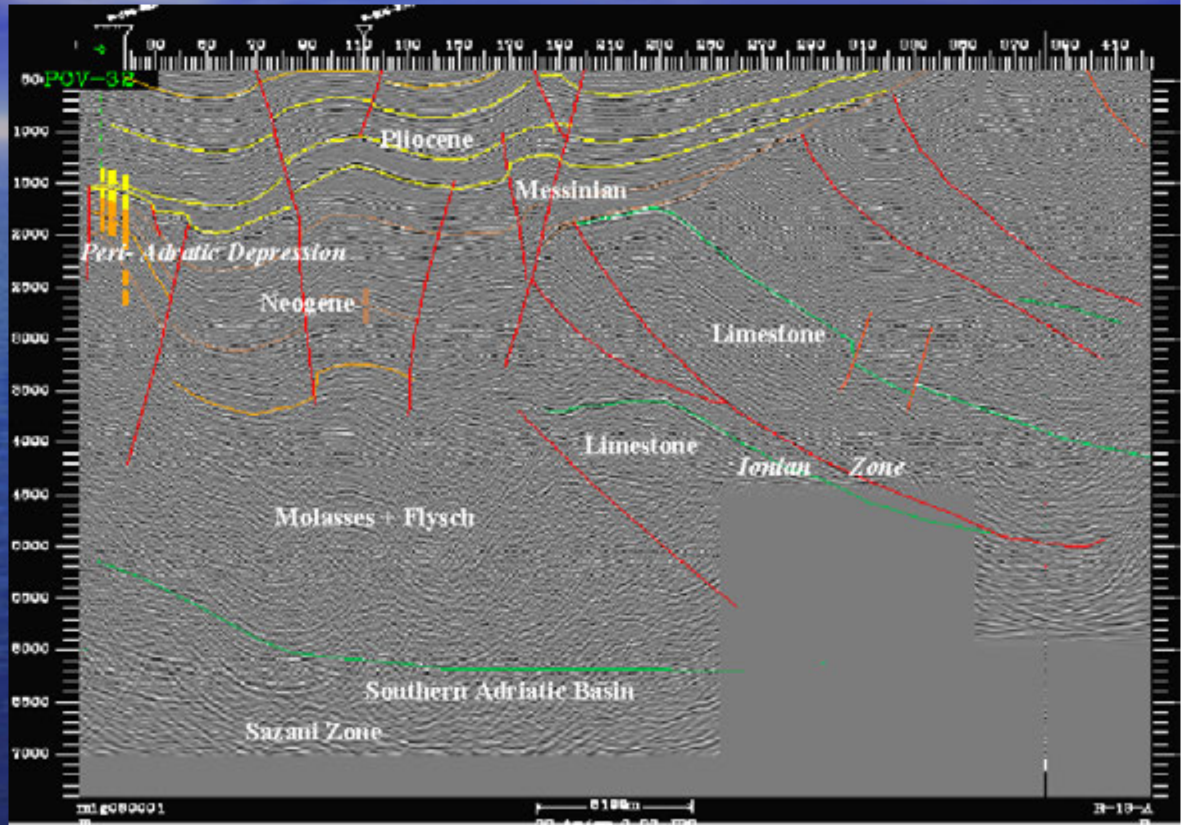
IP Real Section: New survey and interpretation geoelectric method (1978-) (After Alikaj P.)

Saint Nicolas Property, Polymetallic Deposit, Mexico



Oil and Gas Exploration

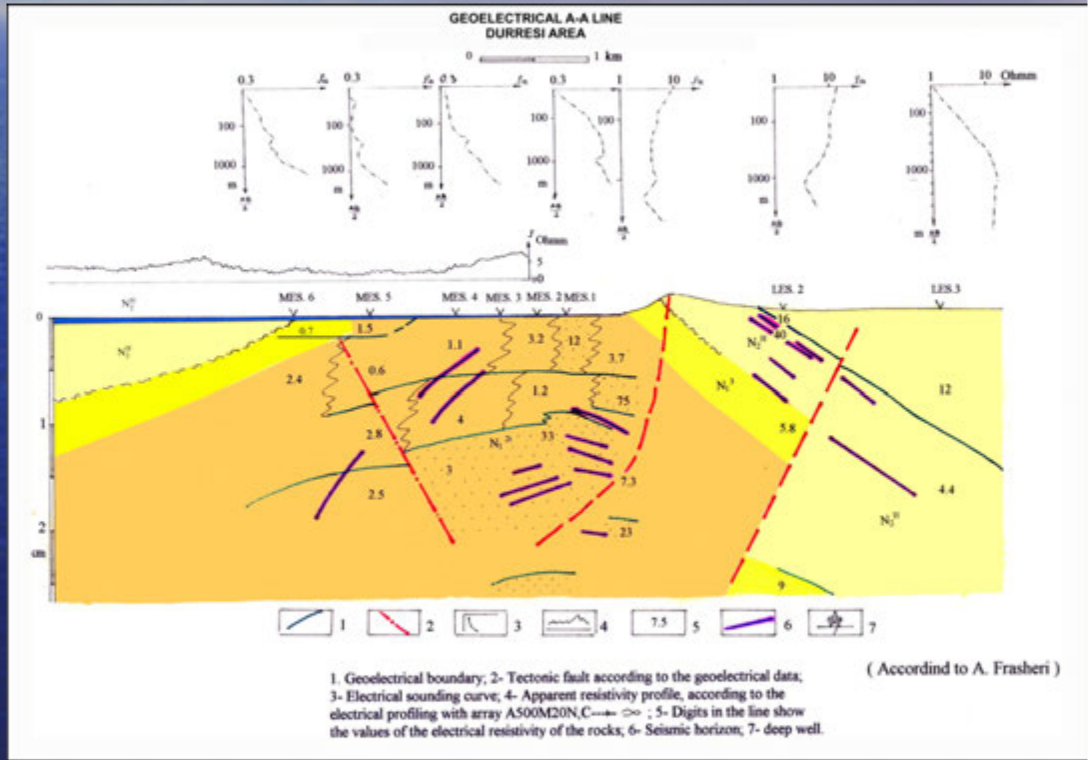
- **Integrated geological-geophysical Oil and Gas Exploration and deep wells design**
- **(P. Nishani, L. Lubonja, A. Frasheri) (1964-), V. Silo (1973-).**
- **Well logging studies, overpressures studies**
- **(R. Lico) (1964-)**



Ardenica-Kolonja Seismic Line
(Nishani P., coauthor)

(After ALBPETROL)

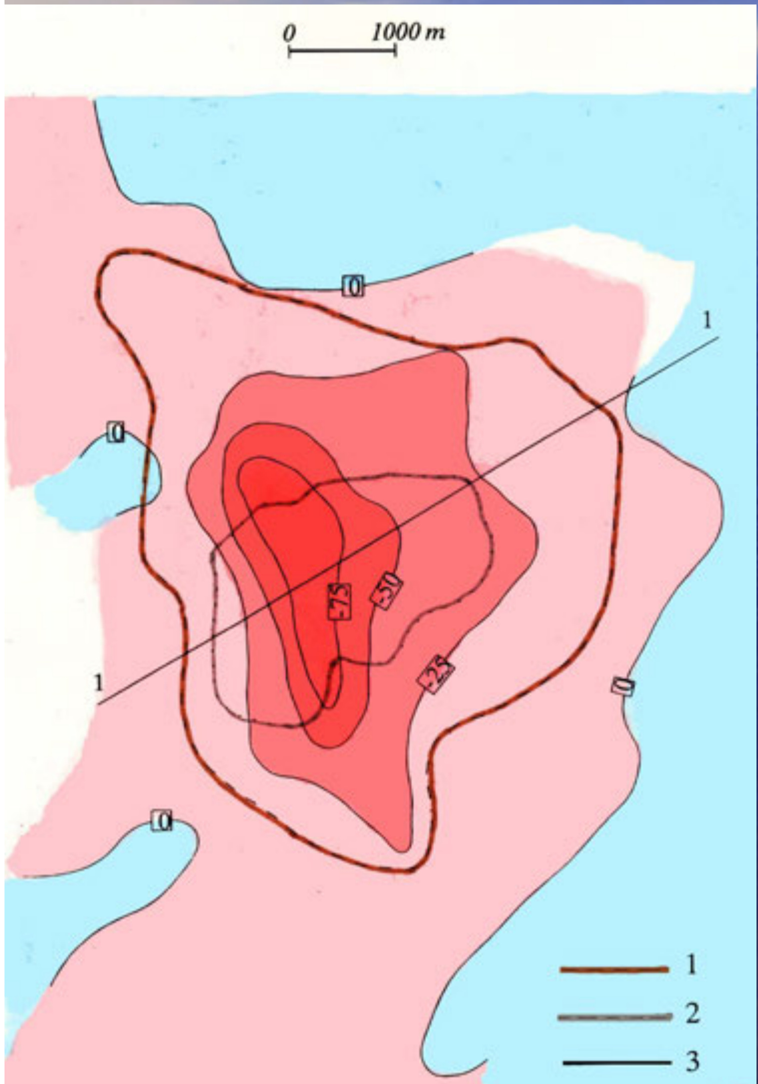
Marine Geoelectrical surveys in Albanian Adriatic Shelf
(A. Frasheri) (1975-1991).



Durresi-Palla Cape Adriatic Shelf area

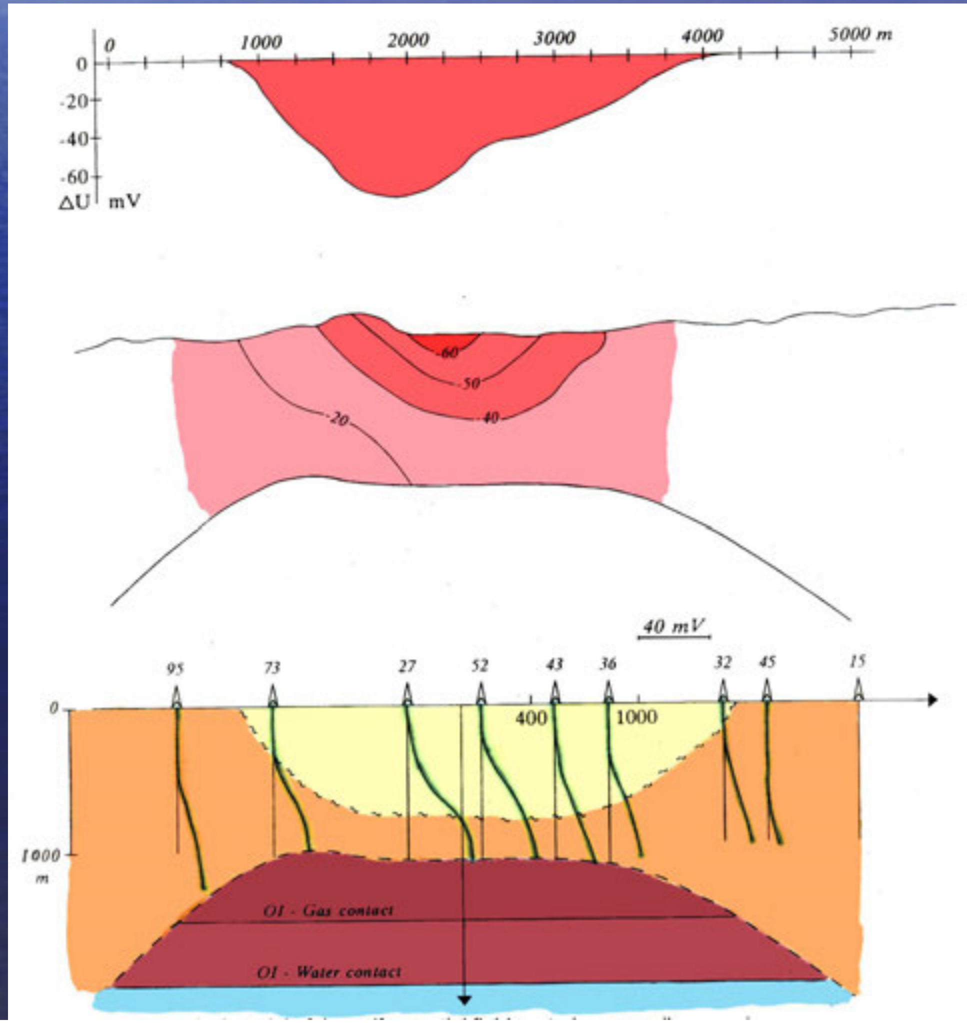
Direct Oil Exploration
(A. Frasheri, R. Lico) (1975-1986).

Self Potential Field Map over Ballsh Oil and Gas Reservoir



Self Potential Profile over

Ballsh Oil and Gas Reservoir



Physical & Mathematical Modeling

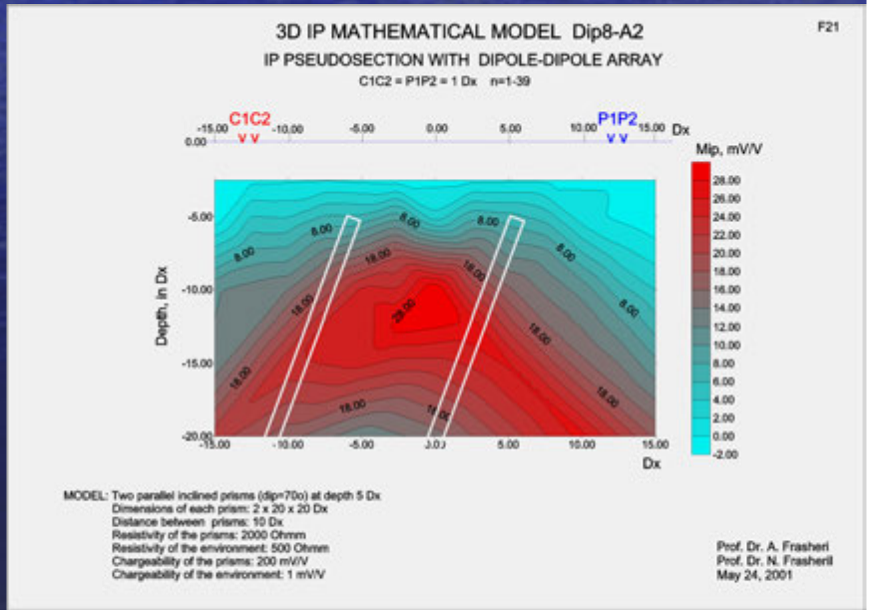
- Application of mathematical methods in data processing and interpretation of geophysical information (Gravity, Magnetic, Electric), with the aid of computers, compilation of algorithms and programs for these purpose.

  (Since 1972) (L. Lubonja, A. Frasheri, S. Bushati,

  P. Alikaj, G. Beqiraj, N. Frasheri)

Last studies:

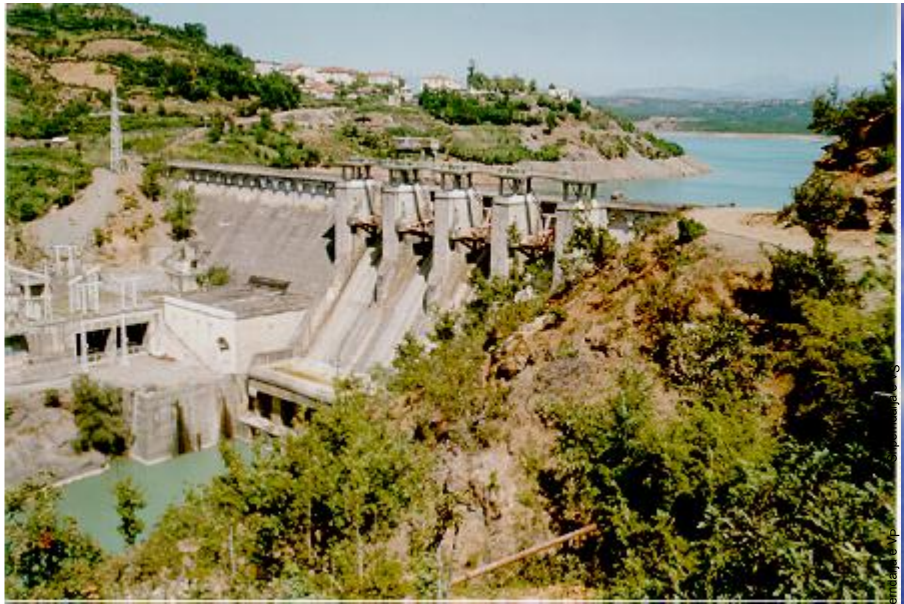
- Dipole – dipole and pole-dipole survey configurations in the framework of the theorem of reciprocity.
- Some considerations on IP data inversion.

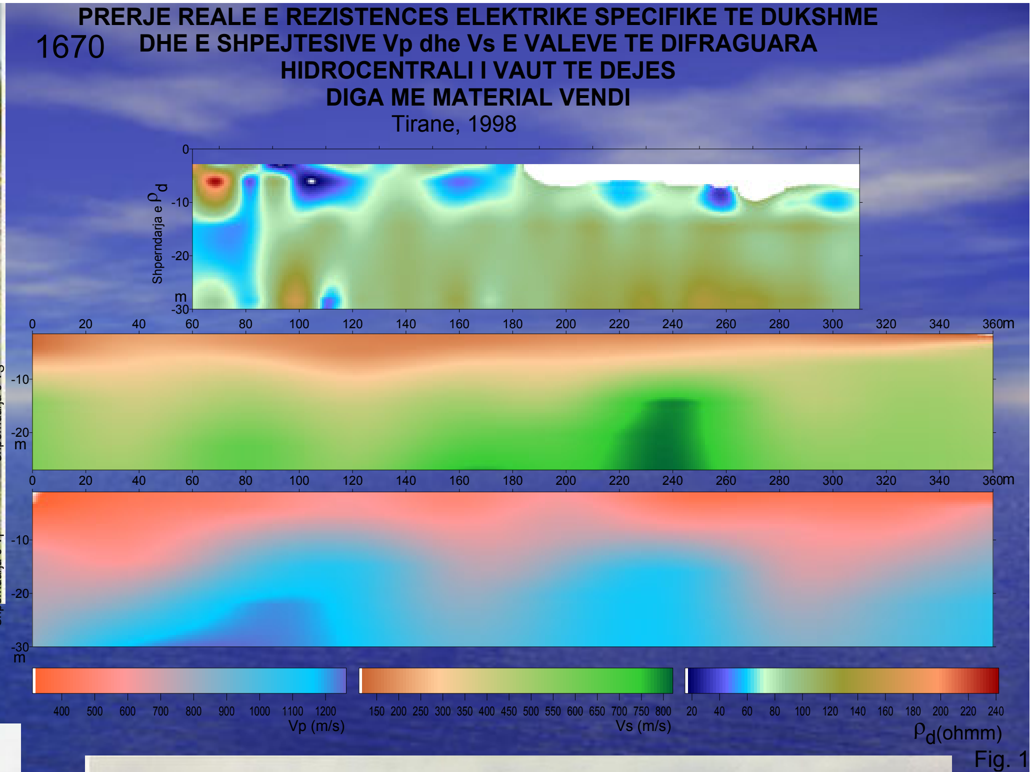


Engineering and Environmental Geophysics

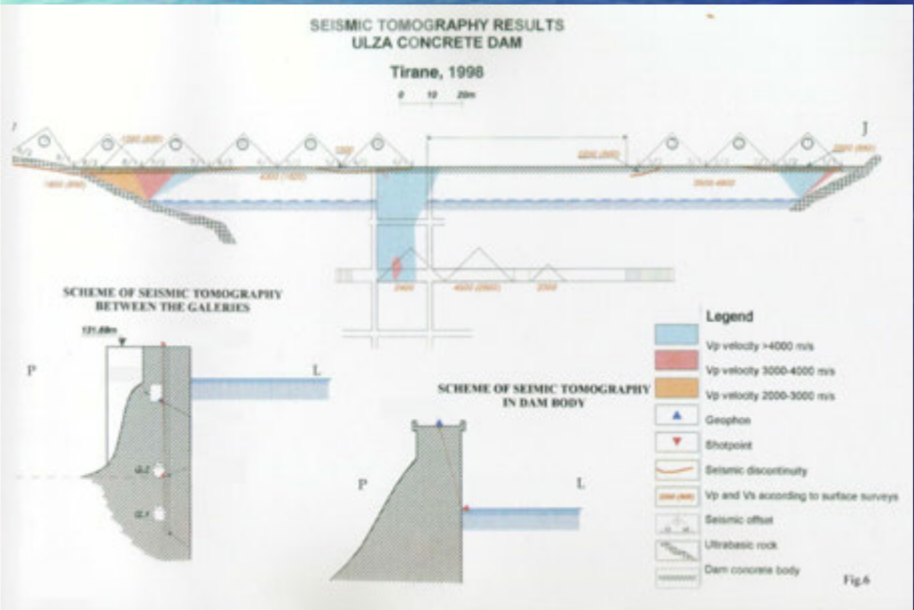
(Since 1982),(A.Frasheri, P. Nishani, P. Alikaj, S. Bushati)

- Seismic and geoelectric tomography for in-situ:
  - Dam investigation.
  - Slope stability and landslide investigation.
  - Environmental impact evaluation.
  - Ground and rocks investigation in the dam area.
  - Karstic zones investigation.
  - Soil and rocks investigation in the construction area, highways, tunnels etc.
  - Evaluation of the quality of the concrete during the construction of the works, in the airports runways etc.
  - Landfill investigation





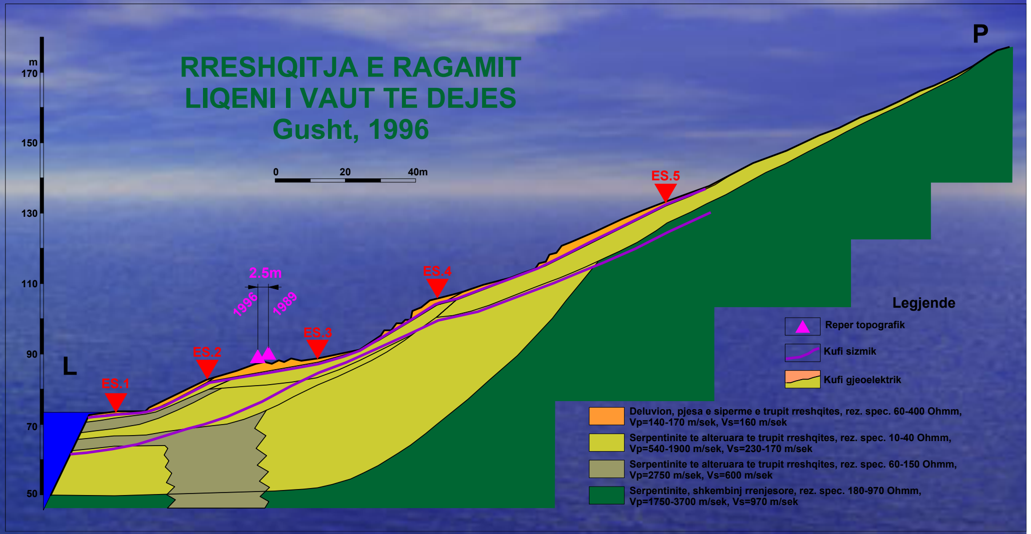
Concrete Dam- Seismic investigation

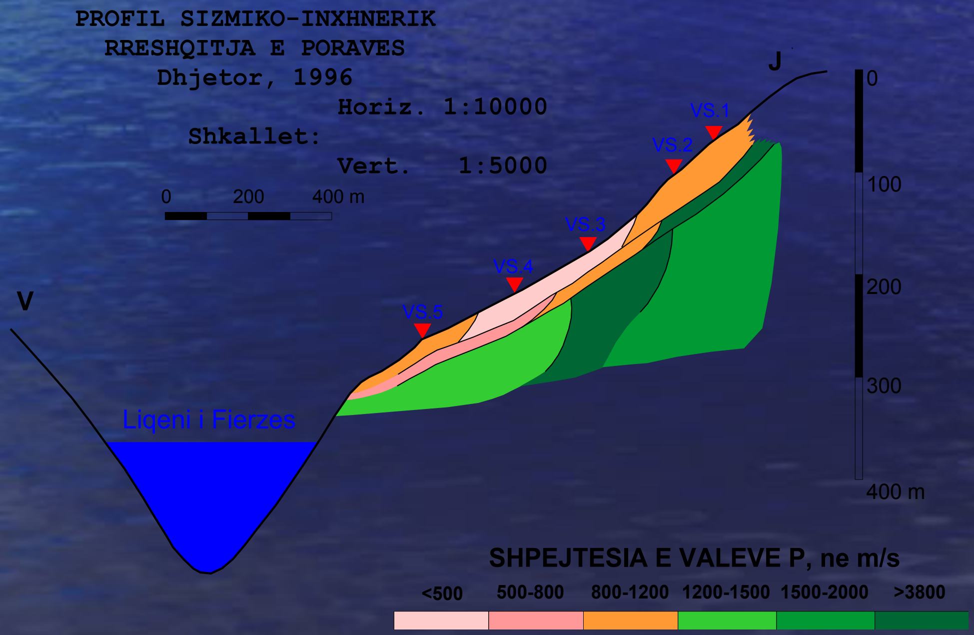


Raw Material Qyrsaqi Dam

1671

Landslide Investigation



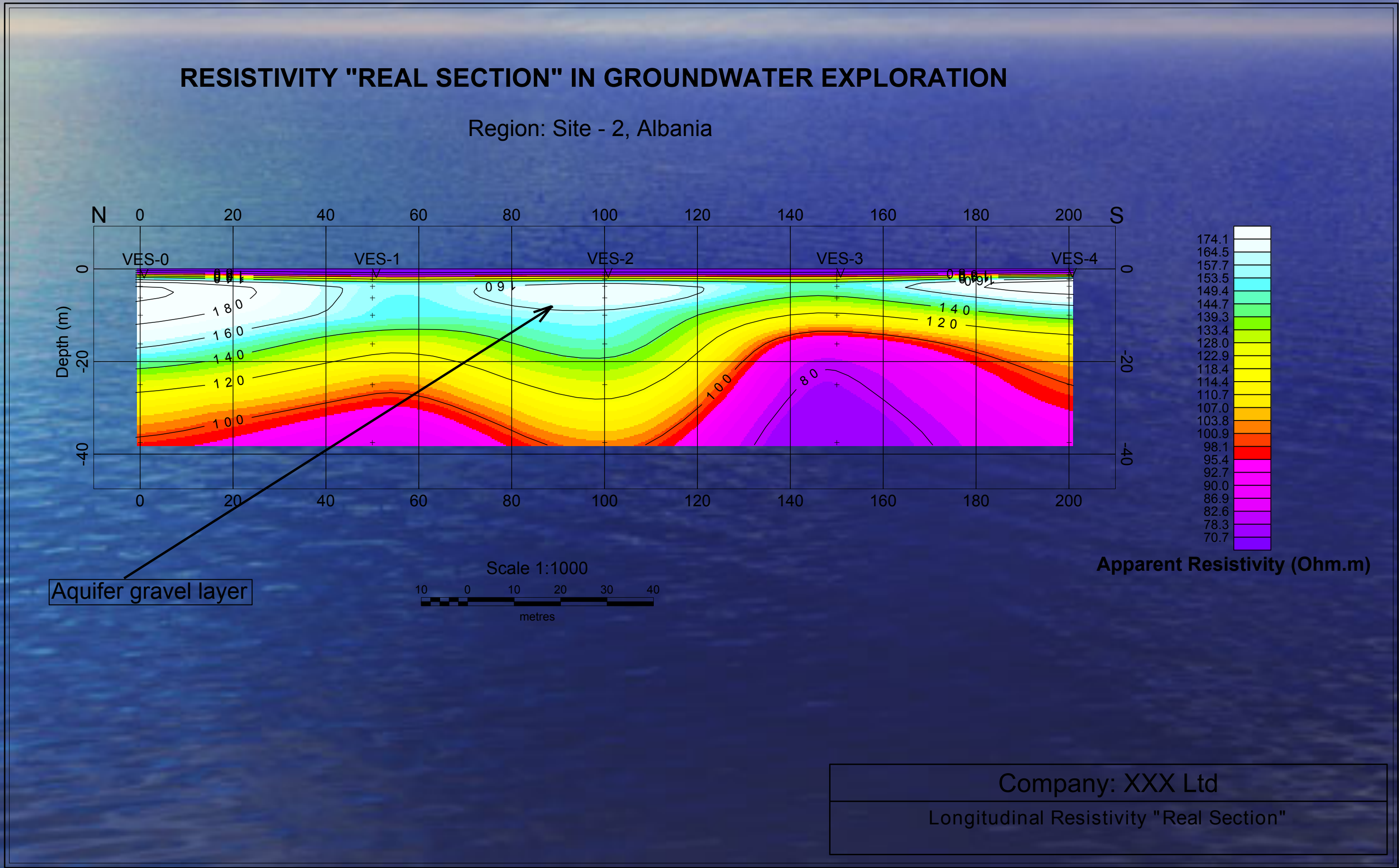


Filled by alluvium Small Prespa Lake

Hydrogeological Geophysical Exploration

(P. Alikaj, A. Frasheri)(1964-)

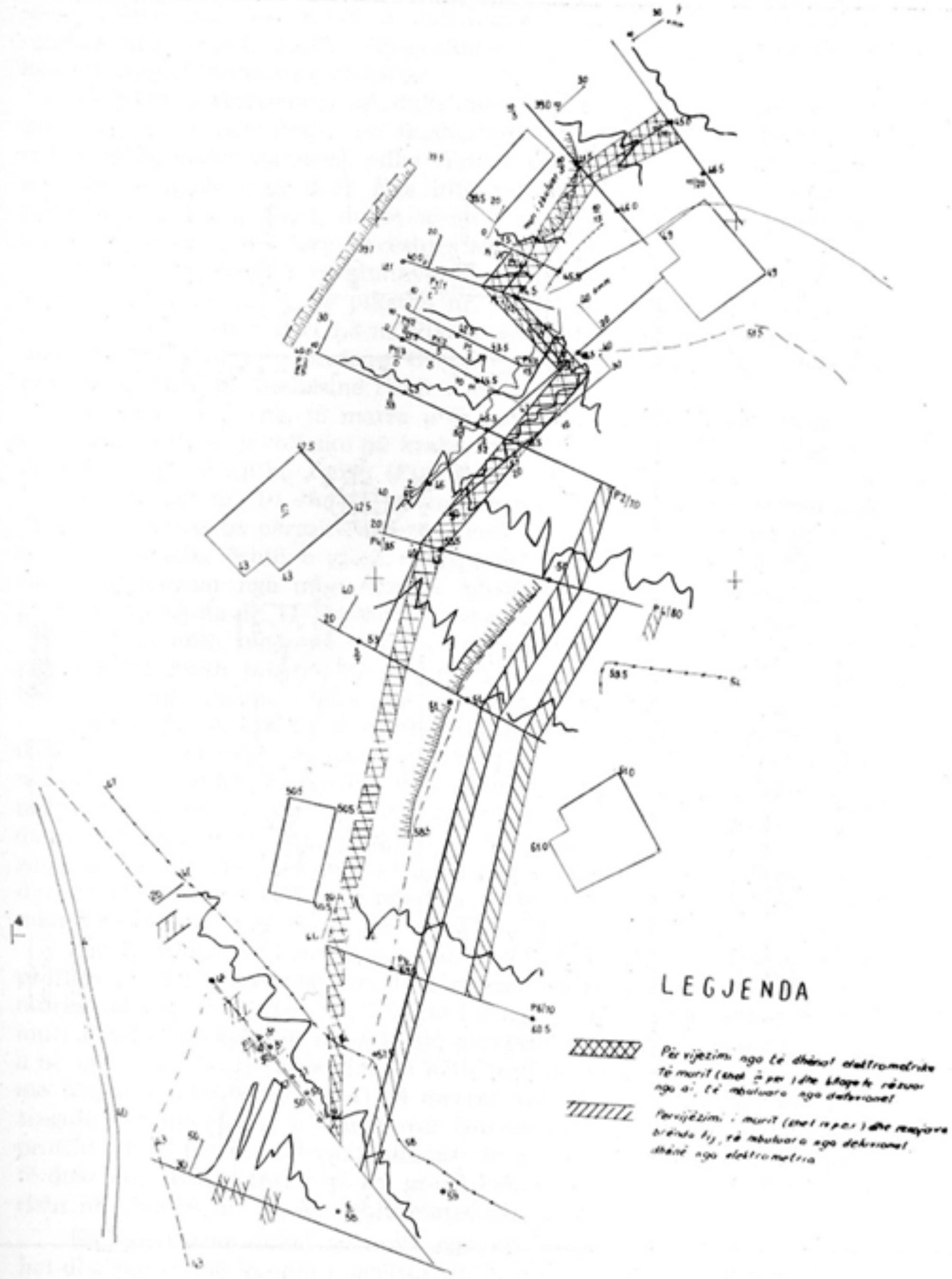
After P. Alikaj, 2004



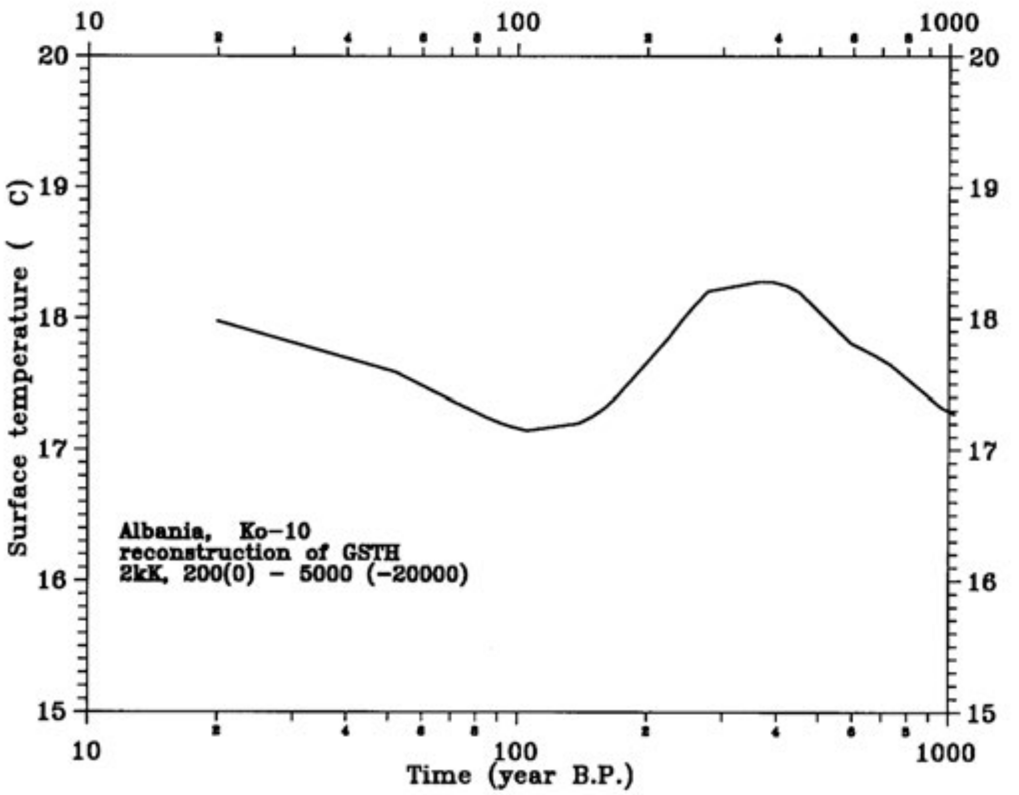
Archaeological Geophysical Research

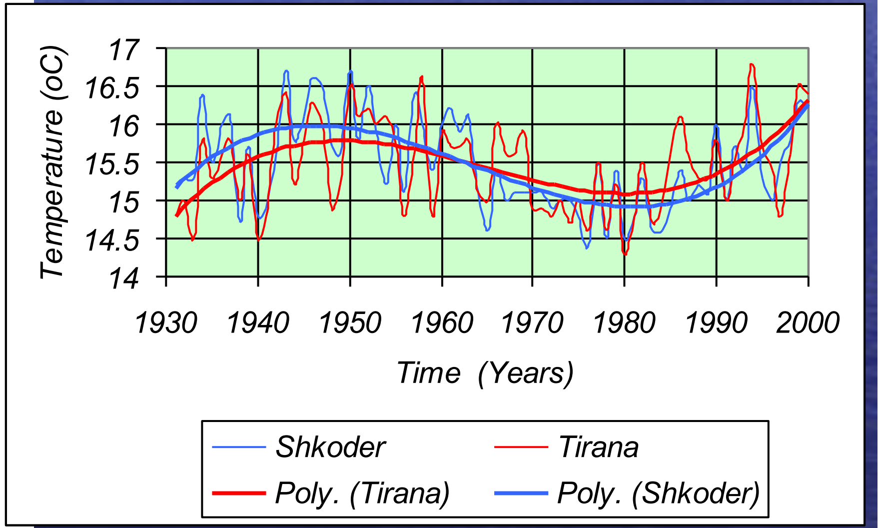
(A. Frasheri, R. Avxhiu)

(1975-)



Paleoclimate change (2002-onwards)
(Frasheri A.)





UNIVERSITY TEXT BOOX

19 books for Branch of Geophysics, 4 books for Geological Branch and 5 monographs. **1962-2005**, (in Albanian)

University Publishing House, Tirana.

Geophysical Branch

- **Gravity Surveys, Exercises**
- **Magnetic Surveys, adoption**
- **Electrical Exploration**
- **Electrical Exploration, Exercises**
- **Waves Theory**
- **Seismics**
- **Well logging**
- **Radiometry**
- **Geophysical method application for solving of the geological problems**
- **Physical properties of the minerals and rocks**
- **Geophysical Equipment**
- **Some equipment for the direct current geoelectric surveys**

Geological, oil and Gas Engineers, Mining Engineers

- **Applied Geophysics: v. 1. Gravity**
  v. 2. Magnetics
  v. 3. Geoelectrical Methods
  v. 4. Seismics and Radiometry

...

- Well logging
- Geophysical Methods for solving of the Mining Problems

Published Monographs:

- Karst and geophysical methods for investigation, University Publishing House, Tirana, 1985.
- Geophysical and Geochemical Problems for copper and chromites exploration, University Publishing House, Tirana, 1993.
- Atlas of Geothermal Resources in Albania. Published by Faculty of Geology and Mining, 2004.
- Geothermal Energy Resources in Albania and platform for their use. Published by Faculty of Geology and Mining, Tirana 2010.

Thank you very much for your attention

CURRICULUM VITAE

Emri **Alfred**
Mbiemri **FRASHERI**

Emri babait **Irfan**
Nëna **Zejnepe**
Date lindja **20 prill 1935**
Vendi i lindjes **Korçë**
Bashkëshortja **Marika,** Inxhiniere Mekanike
Fëmijët: **Ermali,** Jurist, PhD shkenave juridike.
Edita, Pedagoe e italishtes, M.Sc.
Vend banimi Rruga Durresit, Pall.7, Shk.1, Ap.6, Tiranë

Internet site www.Yahoo.com. and Google: www."Alfred Frasheri"
Tel: (04) 222 5160
Mob: 06823 80260
E-mail: Alfred.frasheri@yahoo.com

1. Arsimi Universitar : Inxhiner gjeolog (specializuar ne gjeofizike ne vitin 1961 ne degen e Gjeologjise te Fakultetit te Inxhinerise ne Universitetin e Tiranes).

2. Arsimi Pasuniversitar :

1) **Kandidat i Shkencave, 1974**, me temen "Vetite fizike te kromshpineliteve dhe te shkembinjve ultrabazike te masivit te Tropojes, ne lidhje me anomalite e pritshme gjeofizike", Vendim Nr. 20, date 15/02/1975.

2) **Doktor i shkencave, 1988**, me tezen "Studimi i perhapjes se fushes elektrike ne mjedise elektrike heterogjene", Vendimi Nr 178, date 09/07/1988

3) **Kurse pasuniversitare** 2 muaj Trajtim Sinali ne vitin **1984** ne Universitetin Po et Pays d'Adour, France.

4) **Marrje dhe Shkembim Pervoje** ne Universitete dhe ne institucione shkencore jashte shtetit:

Vizita studimore (2-4 javore)

1992: University of Study of Bari, Italy, University of Study of Milan, Italy, Institute of Geology and Mineral Exploration of Athens, Greece, Geophysical Institute of Acad. Of Science, Prague, ELGI, Budapest, Hungary, University of Budapest, Hungary.

1993 Geophysical Institute of Acad. Of Science, Prague.

1993-1996 University of Leeds, UK, University of Thessaloniki, Geophysical Institute of Acad. Of Science, Prague.University of Thessaloniki, University of Study of Milan, Italy, Geophysical Institute of Geophysics, Academy of Sciences, Prague.

a) Imperial College, Royal School of Mines, London, UK, Institute of Geology and Mineral exploration of Athens, Greece, University of Ulster at Coleraine, Environmental School, UK, University of Thessaloniki.

b) PDAC'1997 Annual International Convention&Trade Show, March 9-12,1997 , Toronto, Canada and QUANTEC. IP, Inc. March 12-25,1997, Downwater, Canada.

1998. Lektor i ftuar ne Summer School: Geothermal Days, Oregon Institute of Technology, Klamath Falls.
1999. Lektor i ftuar ne Summer School: Geothermal days, Ohrid, Macedonia.
2000, 2001 Lektor i ftuar ne Post-graduate Summer School of QUANTECGEOSCIENCE Inc. Toronto, Canada, Korrik-Gusht 2000 dhe Gusht-shtator 2001.

c) Pergatitja e Planit Mesimor te Shkolles
d) Pergatitja e Programit te lendes "Bazat teorike te gjeofizikes se zbatuar"
e) Leksionet e lendes "Bazat teorike te gjeofizikes se zbatuar"

2004. Lektor i ftuar ne Summer School: Geothermal days, Zakopanie, Poloni.

Tituj Shkencore : Pedagog 1961.
Pedagog i pare 1968.
Docent 1981, vendim Nr 40, date 30/06/1981
Profesor 1989, vendim Nr 210 date 27/12/1989

Gjuhe te huaja : Frengjisht (provimi date 17/05/1983).
Rusisht (provimi date 17/12/1964).
Italisht
Anglisht

Curriculum Profesional :

Dhjetor **1998**, e ne vazhdim, pension, Profesor i jashtem ne Seksionin e Gjeofizikes,Departamentin e Shkencave te Tokes.

2002- ne vazhdim- Expert of European DataBank Sustainable Development (EUDB)

1989-1998 Profesor ne Seksionin e Gjeofizikes, Departamentin e Shkencave te Tokes.

1993- 1994 Drejtor i Departamentit te Gjeologjise

1994- 1996 Drejtor i Departamentit te Shkencave te Tokes

1992- 1993 Pergjegjes i Katedres se Gjeofizikes.

1981-1989 Docent ne Katedren e Gjeofizikes

1962-1981 pedagog ne Katedren e Vend Burimeve te mineraleve te dobishme dhe ne katedren e Gjeofizikes.

Qershor 1961 - Nentor 1962 Drejtues teknik i ekspedites gjeofizike ne Ndermarjen Gjeologo Topografike Tirane.

Shkurt-Qershor 1961 Inxhiner interpretator ne Ekspediten sizmike te Ndermarjes Nafte Gaz - Bitumit ne Vlore.

Shtator 1956-Shkurt 1961, Student, Dega |Gjeologjike, Instituti Politeknik dhe ne Shtator 1957 ne Fakultetin e Inxhinjerise, Universiteti i Tiranes

Shtator 1956-Gusht 1956, Teknik ne Baza e Karotazhit, Ndermarrja e Shpim Kerkimeve, Patos

DREJTIMET E VEPRIMTARISE PEDAGOGJIKE NE PERIUDHEN 1961 - 2008

1) Profesor i lendeve “Fizika e Tokes” (2002 e ne vazhdim), lendet me zgjedhje “Gjeotermia” dhe “Gjeofizika inxhinjerike dhe mjedisore” (2005- e ne vazhdim) qe zhvillohen ne vitin e 5-te te deges se gjeofizikes, dhe se bashku me Prof. Vangjel Melo per lenden “Gjeodinamika” (2003 e ne vazhdim) me studentet e vitit te 4-te te deges se gjeologjise.

2). Profesor i lendeve "Elektrometria" qe zhvillohet ne vitet e 3-te dhe te 4-te te deges se gjeofizikes se lendes "Gjeofizika" qe zhvillohet ne vitin e 4-te te deges se Gjeologjise se Mineraleve te ngurte, per vitet 1973- 2002 dhe 1992-1998, perkatesisht.

3) Profesor i lendes "Gjeofizika ne miniera”, qe zhvillohet ne vitin e 5-te te deges se minierave per vitet 1990-1992.

4). Pedagog i lendes "Studimi Gjeofizik i Puseve" per vitet 1961 - 1972, qe zhvillohet ne degen e gjeofizikes dhe ne ato te naftes.

5). Kam zhvilluar kater cikle 2-3 leksionesh ne Departamentin e Shkencave te Tokes ne Universitetin e Milanos (1991, 1993 dhe 1995), ne Departamentin e Gjeologjise dhe te Gjeofizikes ne Universitetin e Barit * ne 1992), ne Departamentin e Gjeologjise se Univesitetit te Leeds ne Angli(1994), ne Departamentin e Gjeologjise se Universitetit te Selanikut (1995), ne Departamentin e Gjeologjise dhe te Gjeofizikes ne Shkollen e Minierave te Kolegjit Imperial te Londres (1996), ne PDAC 1997 Annual International Convention&Trade Show Toronto, Kanada (Mars 1997).

6) Kam zhvilluar cikel te plote leksionesh ne Shkollen pasuniversitare QUANTECGEOSCIENCE Summer School, Toronto, Canada, Korrik-Gusht 2000 dhe ne Gusht-Shtator 2001..

7). Kam punuar per hartimin e planeve mesimore te deges se gjeofizikes qe prej celjes se saj ne 1961 dhe deri me sot. Kam derjtuar hartimin e planit te ri mesimor te orjentimit gjeofizik ne vitin 1993. Kam marre pjese ne hartimin e planeve mesimore te deges se gjeologjise dhe ne vitin 1993 kam drejtuar hartimin e planit te ri mesimor te kesaj dege (1993). Kam marre pjese ne hartimin e planit mesimor per Diplomen e Nivelit -te dyte (Viti 4+5), si edhe te Diplomes Master te Nivelit I-re dhe Master i Nivelit te II-te, specialiteti gjeofizik, ne zbatim te Protokollit te Bolonjes (2007).

8) Kam punuar per hartimin e programit te Shkolles Pas Universitare (ShPU) ne vitin 1995.

9). Kam hartuar programin e lendeve te specialitetit gjeofizik per:

studimet Universitare - Studimi gjeofizik i puseve 1961 - 1972. Elektrometria 1972- 1993. Metodat gjeofizike te kerkimit 1973 - 1993. Interpretimi gjeofizik i rezultateve te studimeve gjeofizike 1965 - 1979. Gjeofizika ne miniera 1990 – 1993, Fizika e Tokes 1994-1998.

Studimet Pasuniversitare Elektrometria. Metoda e polarizimit te provokuar. Metodat gjeofizike te kerkimit te V.B. te mineraleve te dobishme te ngurta. Metodat gjeofizike per kerkimin e V.B. te naftes dhe te gazit. Magnetometria. Studimi i fushave fizike potenciale te Tokes, Gjeodinamika

10). **Kualifikimi Pasuniversitar** : - Udheheqje disertantesh per Kandidat dhe Doktor Shkencash.

.11) **Kurse afatshkurtra me inxhiniere gjeologe-gjeofizike**.

a) Per matematizimin e perpunimit dhe interpretimit te informacionit gjeofizik.
b) Per zbatimin e metodave gjeofizike per studime krahinore dhe per kerkimin e vendburimeve te mineraleve te dobishme.
- Kam marre pjese ose kam drejtuar komisione per provime pasuniversitare, juri per mbrojtje dizertacionesh te kandidateve dhe te doktoreve te shkencave, antar i Komisionit te Larte te Atestimit.

12) Post-graduate Technological Training School of QUANTECGEOSCIENCE Inc. Toronto, Canada, Korrik-Gusht 2000, Gushat-Shtator 2001.

f) Hartimi i Planit mesimor te Shkolles

g) Hartimi i Programit mesimor per Lenden "Bazat teorike te gjefizikes se aplikuar"

h) Leximi i leksoneve te lendes "Bazat teorike te gjefizikes se aplikuar"

13) Lektor i ftuar ne Summer School: Geothermal Days, Oregon Institute of Technology, Klamath Falls, (1998);
14) Lektor i ftuar ne Summer School: Geothermal days, Ohrid, Macedonia (1999)
15) Lektor i ftuar ne Summer School: Geothermal days, Zakopanie, Poloni (2004)
16) Lektor i ftuar ne Summer School: International Summer School of Geothermal Exploration-prospecting–reservoir engineering- monitoring, 28 may - 11 June 2006 Izmir/Turkey (2006)

DREJTIME TE REJA TE VEPRIMTARISE SHKENCORE NE PERIUDHEN 1961-2015

- Lenda "Gjeotermia" ne degen e Gjeofizikes (2005 e ne vazhdim)

- Lenda "Fizika e Tokes" ne degen e Gjeofizikes (2002 e ne vazhdim)

- Studime te gjeofizikes inxhinjerike dhe mjedisit (1982 e në vazhdim)

- Eksperimentimi dhe aplikimi i metodave te reja gjeofizike si metoda e polarizimit te provokuar (1962), mikrorilevimi magnetik (1967) etj per kerkimin e bakrit dhe te kromit.
Rritja e thellesise se kerkimeve gjeofizike te vendburimeve te mineraleve te ngurta. Projektimi dhe ndertimi i aparatures elektrometrike detare 1980. Eksperimentimi dhe zbatimi i studimeve elektrometrike dhe magnetometrike ne shelfin detar te Adriatikut (1976 - 1992).

- Zgjerimi i fushes se aplikimit te metodave gjeofizike per kerkimin e kromit, bakrit, asbestit, boksideve, te shkriferimeve te mineraleve te renda, te rralla e te cmuara, ne studimin gjeologo - inxhinerik, studimet e zonave karstike, ne hidrogjeologji dhe ne miniera; zbatimi i metodes se fushes elektrike natyrore per kerkimin e drejteperdrejte te shtratimeve te naftes e gazit.

- Studime gjeofizike krahinore ne stere dhe ne shelfin detar te Adriatikut (1962-1995 ne stere dhe 1976-1992 ne shelfin detar).

- Zbatimi i metodave matematikore ne perpunimin dhe interpretimin e informacionit gjeofizik ne Komputer. Ndertimi i algoritmeve dhe hartimi i programeve per kete qellim (1974- e në vazhdim).

- Studime gjeotermike si edhe te burimeve te energjise gjeotermike ne Shqiperi (1989 e në vazhdim). Bashkautor i Atlasit Gjeotermik te Europes dhe i Atlasit te Burimeve

Gjeotermale te Europes.

- Kontrolli in-situ i gjendjes se veprave hidroteknike ekzistuese dhe i atyre ne ndertim (1995 e në vazhdim).

- Modelime mathematikore gjeoelektrike (1984 e në vazhdim)

ANETAR I FORUMEVE SHKENCORE

2006. Ekspert i Programit Balwois (Water Observation and Information System for Balkan Countries) (www.Balwois).

2000- 2004: Anetar i Kryesise se Bashkimit Shqiptar te Gjeoshkencetareve dhe Inxhinjereve, 1998-1999 kryetar.

1989 - Anetar i Shoqates se Gjeologeve te Shqiperise.

1992- e ne vazhdim: Anetar i Shoqates se Gjeofizikeve te Shqiperise, 1992-1998 kryetar.

1991 - Anetar Nderi i European Association of Geoscientists and Engineers (EAEG).

1994 - Anetar i Shoqates se Kerkuesve Gjeofizike te Amerikes (SEG)

1993 - Anetar Nderi i Shoqates se Gjeofizikeve te Ballkanit.

1995- Anetar i International Geothermal Association.

1993-1997- Anetar i Komisionit Kualifikimit Shkencor, prane Keshillit te Ministrave te R.SH.

1992- 1996 - Anetar i Keshillit Shkencor te Universitetit Politeknik.

1989- 1996 - Anetar i Keshillit Shkencor te Fakultetit te Gjeologjise e Minierave.

1992- 1995 - Anetar i Bordit Drejtuse te Projektit TEMPUS per Shqiperine.

1989- 1993 - Anetar i Komisionit te larte te Atestimit prane Keshillit te Ministrave.

1991- 1992.- Anetar i Komitetit te Shkencave dhe Teknologjise.

1987- 1993.- Anetar i Komisionit te Posacem te Mbrojtjes se Disertacioneve ne fushen e gjeologjise.

1989 - 1991. Anetar i Keshillit Shkencor te Universitetit te Tiranes

1983 - 1991. Anetar i Seksionit te Gjeologjise ne Komitetin e Shkencave dhe Teknikes se Republikes se Shqiperise.

1973 - 1983. Anetar i Seksionit te Gjeologjise ne Akademine e Shkencave te Republikes se Shqiperise.

1987 - 1991. Anetar i Keshillit Konsultativ Shkencor te Naftes dhe Gazit ne Ministrine e Burimeve Minerare dhe Energjitike.

1975 - 1987. Anetar i Keshillit Shkencor te Institutit gjeologjise se Naftes dhe Gazit ne Fier.

UDHEHEQJE TE DISERTACIONEVE DHE TE STUDENTEVE DIPLOMANTE

- Udheheqje te DISERTACIONEVE

1. Radium Avxhiu - 1979 - Ndermarja Gjeofizike e Tiranes.
2. Rushan Lico - 1980- Katedra e Gjeofizikes.
3. Bejo Duka - 1981 Katedra e Fizikes
4. Pertef Nishani 1985 - Katedra e Gjeofizikes

5. Ludvig Kapllani 1986 Ndermarja Gjeologji Gjeodezi Tirane
6. Vasillaq Leci -1988 Ekspedita Gjeologo-Gjeofizike Detare Durres
7. Perparim Alikaj 1989 Katerda e Gjeofizikes
8. Vladimir Veizaj 1996 Instituti i Naftes dhe i Gazit

- Udheheqje te STUDENTEVE DIPLOMANTE

Nga viti 1963 deri 2008 jane dhjetra studente diplomante te specialitetit gjeofizik qe kam drejtuar per pergatitjen e Projekt Diplomave.

LISTA E PUNIMEVE SHKENCORE DHE BOTIMEVE
I. MONOGRAFI TE BOTUARA

1. R. Eftimi, A. Frashëri, 2016. Ujërat termalë dhe mineralë të Shqipërisë. Shtëpia Botuese e Librit Shkollor e Re, Shtypur në PRINT AL, Tirana, 2016.
2. Frashëri A., etj. 2013. Atlasi gjeotermal i Shqipërisë dhe platformë e shfrytëzimit të nxehtësisv së Tokës. Botim i Akademisë sv Shkencave e Shqipërisë dhe Fakultetit të Gjeologjisë dhe Minierave. Shtypshkronja Kristalina KH, Tiranë.
3. Frashëri A., Kodhelaj N., 2010. Burimet e energjisë gjeotermale në Shqipëri dhe platformë për shfrytëzimin e saj. Botim i Fakultetit të Gjeologjisë dhe të Minierave, Universiteti Politeknik i Tiranës, Shtypshkronja KLEAN, Tiranë.
4. Frashëri A., Londo A., A.Shtjefni, Çela B., Kodhelaj N., Pano N., Alushaj R., Bushati S., Thodhorjani S., 2008. Sistemet gjeotermale të ngrohjes dhe freskimit të godinave. Monografi, Universiteti Politeknik i Tiranës.
5. A. Frashëri, Beqiraj G., Frasheri N. 2008. A review on application of geophysical methods for exploration of copper and chrome ores in Albania. (In English), Publ. Academy of Sciences, Tirana.
6. A. Frashëri, V. Çermak, Rushan Liço, Nazif Kapedani, Fiqiri Bakalli, Burhan Çanga, Enkeleida Jareci, Edlir Vokopola, Hilmi Halimi, Esat Malasi, Jan Safanda, Milan Kresl, Lenka Kucerova, Peter Stulc, 2004. " Atlasi i Burimeve Gjeotermale ne Shqiperi", Botuar nga Fakulteti i Gjeologjise dhe i Minierave dhe Akademia e Shkencave.
7. Frashëri A. 2000. Geothermal energy in Europe, State of the Art and necessary actions and measures to accelerate the development.- Albania. IGA & EGEO Questionaire 2000.
8. A. Frashëri, V. Çermak, Rushan Liço, Nazif Kapedani, Fiqiri Bakalli, Burhan Çanga, Enkeleida Jareci, Edlir Vokopola, Hilmi Halimi, Esat Malasi, Jan Safanda, Milan Kresl, Lenka Kucerova, Peter Stulc, 1995. Geothermal resources of Albania. Botuar në " Atlas of Geothermal Resouces in Europe". European Commission, Hanover 2002.
9. E. Pumo, A. Frashëri, A. Tashko. 1993 "Probleme te kerkimeve gjeofizike-gjeokimike te V.B. te bakrit dhe te kromit ne Shqiperi". Shtepia Botuese e Librit Universitar, 83 (104) faqe
10. Frashëri A. etj. 1992. Greothermal resources of Albania. Botuar në Geothermal Atlas of Europe, (in English), Germany, International Heat Flow Commission, 1992.
11. N. Konomi, A. Frashëri, M. Muco, L. Kapllani, S. Bushati, L. Dhami 1985 "Karsti dhe

studimi i tij me metoda gjeofizike". Botim i UT, (bashkeautor) 105 (203)* faqe.

12. A. Frashëri, 1974 "Vetite fizike te kromshpineliteve dhe te shkembinjve ultrabazike te masivit te Tropojes lidhur me anomalite e pritshme gjeofizike". Disertacion per kerkimin e grades "Kandidat i Shkencave" 173 faqe, botuar me shkurtime 44 faqe ne Vjetarin e Fakultetit te Gjeologjise dhe Minierave. Permbledhje Studimesh, Tirane 1976.

II. MONOGRAFI TE PABOTUARA

1. Frasheri A., Bushati S., Nishani P., Silo V., 2008. Slope stability evaluation and landslide investigation and monitoring using geophysical data. A Monograph, Academy of Sciences of Albania
2. Frasheri A., Nishani P., Kapllani L, Hoxha P., Canga B., Xinxo E., Dima F., Xhemalaj Xh., 1998. Studim mbi gjendjen fiziko-mekanike te veprave hidroteknike dhe te mjedisit gjeologjik perreth. Tirane.
3. Frasheri A., Çermak V., Kapedani N., Liço R., Çanga B., Jareci E., Kresl M., Safanda J., Kucerova L., Shtulc P. 1995. Atlasi Gjeotermal i Shqiperise.
4. Frasheri A., Çermak V., Kapedani N., Liço R., Çanga B., Jareci E., Kresl M., Çano D.., Kucerova L., Shtulc P. 1994. Geothermal Atlas of External Albanides.
5. A. Frasheri 1987 "Studimi i perhapjes se fushes elektrike ne njedise gjeologjike heterogjene dhe efektiviteti i elektrometrise detare ne studimin e struktures Durres-Kepi i Palles". Disertacion per kerkimin e grades "Doktor i Shkencave".
6. Frasheri A., Çermak V., Kapedani N., Liço R., Çanga B., Jareci E., Kresl M., Safanda J., Kucerova L., Shtulc P., 1995. Geothermal Atlas of Albania.
7. Frasheri A., Cermak V., Liço R., Kapedani N., Bakalli F., Halimi H., Vokopola E., Malasi E. Çanga B., Jareci E., Safanda J., Kresl M., Kucerova L., Stulc P. 1996. Geothermal resources of Albania. Atlas of Geothermal Resources in Europe, (in English), European Commission.
8. Frasheri A., Nishani P., Kapllani L, Hoxha P., Canga B., Xinxo E., Dima F., Xhemalaj Xh., 1998. Study of the physical-mechanical status of hydrotechnical constructions and surrounding geological medium.
9. Frasheri A., 2000. Geothermal energy in Europe, State of the Art and necessary actions and measures to accelerate the development.- Albania. IGA & EGEO Questionaire 2000.

III. LIBRA TE NDRYSHEM

1. Frashëri A., Beqiraj G., Frashëri N., Bushati S. 2016. Mathematizimi dhe informatizimi i problemeve gjeofizike gjatë viteve në Shqipëri. Botim i Akademisë së Shkemcave të Shqipërisë, Nw shtyp, Tiranë

2. Papic Peter (Editor), 2015. Mineral and termal waters of Southeastern Europe (Environmental Earth Sciences)- Albania (R. Eftimi & A. Frashëri, autors). Springer, 2015.

* 105 (203) - Numri i faqeve te shkruara nga A. Frasheri dhe numri i pergjithshem i faqeve.

3. Frashëri A., 2015. Tomori, mali që ne shqiptarët e quajmë Baba. Botim digital: https://archive.org/download/AFrasheriTOMORI/A%20Frasheri%20TOMORI.pdf

4. Frashëri A., 2015. Mendimet dhe shqetsimet nuk i mbylla në sirtar. Botim i "Shtëpisë Botuese të Librit Shkollor e e", Tiranë. Botim digital: https://archive.org/details/MendimetDheShqetesimetNukIMbyllaNeSirtarALfredFrasheri

5. Frashëri A., 2015. Studime dhe kërkime gjeofizike, 1961-2015. Digital format. https://archive.org/download/FrasheriASTUDIMEDHEKERKIMEGJEOFIZIKE19612014OPTIM/Frasheri%20A%20-%20STUDIME%20DHE%20KERKIME%20GJEOFIZIKE%20%201961-2014%20%20OPTIM.pdf

6. Frashëri A., Frashëri N., 2014. Frashëri në historinë e Shqipërisë. Botim i dyte, Shtëpia Botuese e Librit Shkollor të Ri, Tiranë.

https://archive.org/details/FrasheriNeHistorineEShqiperise2014

7. Frashëri Albert., Frashëri Alfred, 2014. " Rilindja Kombëtare Shqiptare-Studime për Idetë e Rilindjes Kombëtare. Shtëpia Botuese e Librit Shkollor të Ri, Tiranë.

8. Frashëri A., 2012. Gjeofizika inxhinierike dhe mjedisore. Botimi i dytë, Botim i Fakultetit të Gjeologjsë dhe Minierave, Universiteti Politeknik i Tiranës. GOOGLE, Gjeofizika, Libri Gjeofizika Inxhinierike.

7. Frashëri A., 2012. Gjeomonumente që tregojnë historinë e Tokës Shqiptare. Botim i "Shtëpisë Botuese të Librit Shkollor e e", Tiranë.

8. Frashëri A., Mati A. , Mati T., 2011. Shkencat e Tokës. Tekst mësimor për shkollën e mesme. Shtëpia Botuese e Librit Shkollor të Ri, Tiranë.

9. Frashëri A., Bushati S., Nishani P., Liço R. 2008. Gjeofizika Shqipare në vite. Tiranë.

10. Frashëri A., Frashëri N., 2008. Frashëri në historinë e Shqipërisë. Shtëpia Botuese Dudaj, Tiranaë.

11. Frashëri A. 2005. Gjeofizika Inxhinjerike dhe Mjedisore". CD variant, Botim i Fakultetit të Gjeologjise e Minierave dhe Akademia e Shkencave.

12. Frashëri A.1898. "Gjeofizika ne miniera". Botim i UT.

13 Frashëri A, Avxhiu R, Malaveci M, Alikaj P., Leci V,, Gjevreku Gj.. 1986. "Elektrometria". Botim i UT, (bashkeautor). 497 (800) faqe.

14. A. Frashëri, G. Beqiraj, Dh. Tole, I. Cani, N. Frasheri, P. Alikaj, 1985. "Elektrometria". (Mesime praktike). Botim i UT, (bashkeautor). 415 (611) faqe.

15. 1973 "Material plotesues per problemet e elektrometrise". Pershtatur nga A. Frasheri, R. Avzhiu. Botim i UT. 113 (231) faqe.

16. A. Frashëri, E. Sulstarova, Sh. Aliaj, R. Avxhiu 1972.Perdorimi i metodave gjeofizike per zgjidhjen e detyrave gjeologjike". Botim i UT, (bashkeautor). 260 (450) faqe.

17. A. Frashëri,1970 "Disa aparate per studime elektrometrike me rryme te vazhduar. Botim i UT, ribotim 1973, 1984. 174 faqe.

18. A. Frashëri, L. Lubonja, P. Nishani, R. Avzhiu, S. Kociu, P. Arapi 1970. "Metodat gjeofizike te kerkimit". Botim i UT, ribotim 1983, 1987, 1988, (bashkeautor). 303 (844) faqe.

19. A. Frashëri, R. Lico, K. Papa 1970. "Studimi gjeofizik i puseve". Botim i UT,

(bashkeautor). 210 (284) faqe.

20. L. Lubonja, A. Frashëri 1965 "Metoda e polarizimit te provokuar dhe perdorimi i saj per kerkimin e xeheroreve dhe studimin e prerjeve te puseve". Botim i UT. 64 (104) faqe.

21. A. Frashëri 1964. "Gjeofizika Kantierale". Pjesa e I-re per gjeologet Botim i UT 265 faqe.

IV. ARTIKUJ SHKENCORE TE BOTUAR NE SHQIPERI

1. A. Frasheri 1963. "Proceset fiziko-kimike, qe krijojne fushen elektrike natyrore mbi trupat sulfide ne rajonet e Mirdites dhe te Kukesit". Bul. UT. seria e Shkencave te Natyres, Nr. 3, f. 123-136.

2. L. Lubonja, A. Frasheri 1969. "Aplikimi i metodave gjeofizike te reja per kerkimin e kromiteve ne Shqiperine e Veriut". Anuar i Gjeologjise Nr. 3, (bashkeautor). f. 78-91.

3. A. Frasheri 1966. "Influenca e shpateve te brigjeve te lumejve ne rrezultatin e sondimeve elektrike vertikale". Bul. UT. Seria e Shkencave te Natyres Nr. 3. f. 39-47.

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VI. STUDIME
A. TE EMERTESES SE KESHILLIT TE MINISTRAVE DHE TE PROGRAMIT KOMBETAR PER KERKIM DHE ZHVILLIM: GJEOLOGJIA

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2. 1978 "Studim mbi ndertimin e kurbave teorike te sondimeve vertikale elektrike ne stere dhe det me anen e makinave elektronike llogaritese". Fondi i fakultetit Gjeologji dhe Miniera, (bashkeautor - drejtues studimi)

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4. 1981 "Ndertimi gjeologo-gjeofizik i rajonit te Dumrese e perreth dhe projektimi i punimeve te kerkimit". Fondi i Institutit Gjeologjik te Naftes Fier, (bashkeautor - drejtues studimeve gjeoelektrike)

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6. 1981 "Rezultatet eksperimentale te punimeve elektrometrike per studimin e rezervuarit te Zagores". Grupi i studimit te rezervuareve ne zonat karstike prane Keshillit te Ministrave te RSH, (bashkeautor - drejtues studimeve)

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11. 1982 "Pergjithesim i rezultateve te punimeve gjeologo-gjeofizike inxhinerine ne zonat karstike". Fondi i Institutit te Bonifikimit, (bashkeautor - drejtues punimesh).

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22. 1995 Raport mbi rezultatet e studimit te vetive magnetike te ofioliteve. Nentor 1995,(Drejtues Pprojekti).

23. 1995 Veshtrim Paleomagnetik mbi gjeodinamiken e Albanideve. Dhjetor 1995, (Drejtues Projekti_.

24. 1996 Atlas of Geothermal resources of the Republic of Albania. February 1996, (Drejtues Projekti)

25. 1996 Relacion mbi gjendjen e diges se Ragamit dhe te Rreshqitjes ne bregun e liqenit te hidrocentralit te Vaut te Dejes ne Ragam. Tirane, shtator 1996,(Drejtues kerkimi).

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30. Frashëri A., Pano N., Bushati S., Malasi E. 2003. Projekt ide mbi shfrytëzimin integral dhe kaskadë të energjisë së ujërave gjeotermale në Shqipëri", Programi UNDP-GEF SGP, Tirana.

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32. Frashëri A., Simaku Gj., Pano N., Bushati S., Frashëri S. 2003. Projekt ide mbi shfrytëzimin energjisë gjeotermale për ngrohjen dhe freskimin e banesave", Programi UNDP-GEF SGP, Tirana.

33. Frasheri A., Liço R., Bakalli F, Frashëri N., Pano N., Bushati S., Çela B., Prenjasi E., Haska H., Çanga B., 2004. Projekt " Atlasi i Burimeve Gjeotermale ne Shqiperi", Programi Kombetar per Kerkim e Zhvillim, Pasurite Natyrore 2003-2005, Akademia e Shkencave, Fakulteti i Gjeologjise dhe i Minierave.

34. Pano N., Prifti V., Frasheri A. etj. 2006. Projekti "Hidrologjia e Shqiperise" Programi Kombetar per Kerkim e Zhvillim, Pasurite Natyrore 2003-2005, Akadmemia e Shkencave, Fakulteti i Gjeologjise dhe i Minierave.

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36. Frashëri A., Kodhelaj N., 2009. ***Platformë për energjinë gjeotermale në Shqipëri, (Pjesa 2),*** Skenarët e shfrytëzimit të energjisë gjeotermale në të gjithë burimet dhe puset e ujërave termominerale në Shqipëri. Programi Kombëtar për Kërkim e Zhvillim, Uji dhe Energjia, 2007-2009.

B. TE EMERTESES SE DIKASTERIT DHE TE SHKOLLES SE LARTE (DREJTUES STUDIMI)

1. 1964 "Raport mbi punime tematiko-shkencore per kerkimin e kromiteve me metoden e potencialeve te polarizimit te provokuar ne rajonin e Kukesit gjate vitit 1963". Fondi i Gjeologjise, (bashkeautor)

2. 1964 "Raport mbi rezultatet e punimeve tematiko-eksperimentale, gjeofizike me metoden e sondimeve elektrike vertikale ne basenin e lumit Mat, Fan i Madh dhe Fan i Vogel gjate vitit 1963". Fondi i Gjeologjise, (bashkeautor).

3. 1964 "Rezultat i punimeve tematiko-shkencore me metoden e sondimeve elektrike vertikale ne basenin e lumit Mat, Fan i Vogel dhe Zmeje gjate vitit 1964". Fondi i Gjeologjise.

4. 1965 "Perdorimi i metodave gjeofizike per kerkimin e shkriferimeve te mineraleve te rende, te ralle ne RSH ne vitin 1960-1962". Fondi i Gjeologjise, (bashkeautor).

5. 1966 "Perdorimi i metodave gjeofizike per kerkimin e shkriferimeve te mineraleve te rende". Sektori i elementeve te rende dhe te rralle U.SH.T., (bashkeautor).

6. 1966 "Disa te dhena paraprake per perdorimin e mikrorilevemit magnetometrik ne ndihme te rilevimit gjeologo-strukturor ne shkembinjte ultrabazike". Fondi i Gjeologjise.

7. 1968 "Studim mbi mundesine e perdorimit te mikrorilevemit magnetometrik ne ndihme te rilevimit gjeologo-strukturor ne rajonet e ndertuara nga shkembinjte magnetike". Fondi i Gjeologjise, (bashkeautor).

8. 1966 "Perdorimi i metodave elektrometrike per studimin e bazamentit te shtratimeve te lumejve qe vendosen mbi shkembinj sedimentare, ne rajonet e Kervajes dhe Urakes, ne vitin 1965". Fondi i Gjeologjise, (bashkeautor).

9. 1968 "Raport mbi rezultatet e punimeve magnetometrike eksperimentale ne V.B. e asbestit ne Kodren e Buces ne Puke, te kryera ne vitin 1967". Fondi i Gjeologjise, (bashkeautor).

10. 1973 "Raport mbi rezultatet e punimeve eksperimentale gjeofizike per kerkimin e trupave te mineralizuar te kromit te kryera ne rajonin e Cerrujes (Studenti), Selishte Jugore

dhe Selishte Veriore gjate vitit 1972". Fondi Qendror i Gjeologjise, (bashkeautor).

11. 1976 "Relacion mbi rezultatet e punimeve eksperimentale elektrometrike ne cektinen e Bishtit te Palles". Fondi i Institutit Gjeologjik te Naftes Fier, (bashkeautor).

12. 1982 "Pergjithesimi gjeologo-gjeofizik dhe nafte-gaz mbajtja e rajonit te Amonice-Plloce-Haderaj". Fondi i Institutit Gjeologjik te Naftes Fier, (bashkeautor).

13. 1982 "Pergjithesimi gjeologo-gjeofizik i veriut te Amonices". Fondi i Institutit Gjeologjik te Naftes Fier, (bashkeautor).

14. 1982 "Relacion mbi rezultatet e punimeve eksperimentale elektrometrike ne Kalane e Margellemit dhe perpjekjet per perdorimin e metodave gjeofizike ne kerkimet arkeologjike ne vendin tone". Fondi i Ndermarjes Gjeologjike Tirane, (bashkeautor).

15. 1986 "Studim mbi rruget e rritjes se thellesise se kerkimit te metodave gjeofizike". Fondi i Ndermarjes Gjeologjike Tirane, (bashkeautor).

16. 1986 "Mbi mundesite e perdorimit te metodikes se SVE dhe FEN ne kushtet e ndertimit gjeologjik te vendit tone". Fondi i NKGJGN Fier, (bashkeautor).

17. 1988 "Mbi mundesine e rritjes se thellesise se kerkimit me metodat gjeofizike". Vell. 2 (Algoritme dhe programe). Fondi i Ndermarjes Gjeologjike Tirane, (bashkeautor).

18. 1988 "Algoritmet dhe programet ELETRON 2 dhe ELETRON A". Fondi i INIMA, (bashkeautor).

19. 1989 "Pergjithesimi gjeoelektrik i rezultateve te punimeve elektrometrike detare ne rajonin Kryevidh-Durres-Kepi i Palles, lidhur me ecurime e kerkimit te gazit pas shpimit te pusit Dr-15". Fondi i NKGJGN Fier, (bashkeautor - drejtues i studimeve gjeoelektrike).

20. 1989 "Pergjithesimi gjeologo-gjeofizik-gjeokimik te rajonit te Okshtunit dhe perspektiva nafte-gaz mbajtese dhe e mineraleve te tjera te debishem". Fondi i Institutit Gjeologjik te Naftes Fier, (bashkeautor - drejtues i studimeve gjeoelektrike).

21. 1989 "Studim mbi rruget e rritjes se thellesise se kerkimeve gjeofizike te V.B. te mineraleve te dobishem te ngurte". Fondi Qendror i Gjeologjise, (bashkeautor).

C. STUDIME MBI ZHVILLIMIN E GJEOFIZIKES NE REPUBLIKEN E SHQIPERISE

1. 1963 "Relacion mbi punimet gjeofizike per kerkimin e xeheroreve te kryera ne Republiken e Shqiperise dhe zhvillimi i tyre ne teardhmen". Fondi i fakultetit Gjeologji dhe Miniera, (bashkeautor).

2. 1983 "Kerkimi i derjteperdrejte i V.B. te naftes dhe gazit me metoda gjeofizike". Fondi i Institutit Gjeologjik te Naftes Fier, (bashkeautor).

3. 1977 "Mbi studimin e shelfit detar te Adriatikut". Fondi i Institutit Gjeologjik te Naftes Fier, (bashkeautor).

4. 1981 "Studim mbi gjendjen e elektrometrise dhe zhvillimin e saj ne te ardhmen per kerkimin e naftes dhe te gazit". Fondi i NKGJGN Fier.

5. 1982 "Studim mbi gjendjen dhe zhvillimin e gjeofizikes xeherore ne vendin tone, rruget dhe masat qe duhen marre per zgjerimin dhe thellimine saj, ne perputhje me detyrat qe

shtrohen per kerkim-zbulimin e mineraleve te dobishme te ngurta". Aparati i Keshillit te Ministrave te RSH. Fondi i Ndermarjes Gjeologjike Tirane, (bashkeautor).

6. 1983 "Studim per nivelin shkencor te metodave gjeofizike ne kerkimin enaftes dhe te gazit. Rruget dhe masat qe duhen marre per rritjen e tyre ne te ardhmen". Komiteti i Shkencave prane Keshillit te Ministrave te RSH, (bashkeautor).

7. 1984 "Studim mbi zgjerimin e kompleksit gjeologo-gjeofizik me metodat per kerkimin e drejteperdrejte te V.B. te naftes e gazit ne pjesen qendrore te zones tektonike Kruja". Fondi i fakultetit Gjeologji dhe Miniera, (bashkeautor).

8. 1984. Mbi zgjerimin e komplesit gjeologo-gjeofizik me metodat perkerkimin e drejtperdrejte te naftes dhe gazit ne pjesen qendrore te zones tektonike Kruja. Fondi i Institutit Gjeologjik te Naftes dhe Gazit, Fier, (Bashkautor).

D. STUDIME MBI PERSPEKTIVEN E KERKIMIT TE VENDBURIMEVE TE MINERALEVE TE DOBISHME

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E. RAPORTE MBI REZULTATET E PUNIMEVE GJEOFIZIKE TE PRODHIMIT (DREJTUES PUNIMESH)

1. 1962 "Raport mbi rezultatet e punimeve elektrometrike dhe magnetometrike ne rajonin e Kukesit dhe te Mirdites gjate vitit 1961". Fondi i Gjeologjise, (bashkeautor).

2. 1963 "Raport mbi rezultatet e punimeve gjeofizike ne rajonin e Kukesit dhe te Mirdites gjate vitit 1962". Fondi i Gjeologjise, (bashkeautor).

3. 1963 "Relacion mbi rezultatin e punimeve elektrometrike ne piken e mineralizuar te Thirres ne vitin 1963". Fondi i NSHGJ Topografike, Tirane.

4. 1963 "Relacion mbi rezultatin e punimeve gjeofizike ne shkriferimet e rajonit Seman-Vjose, gjate vitit 1962". Fondi i Gjeologjise.

5. 1969 "Raport i rilevimit magnetometrik per kerkimin e asbestit ne V.B. e asbestit Puke, te kryera per vitet 1967-68". Fondi i Gjeologjise, (bashkeautor).

6. 1982 "Relacion mbi rezultatin e sondimeve elektrike ne rajonin e Dumrese". Fondi i NKGJGN Fier, (bashkeautor).

7. 1984 "Relacion mbi rezultatin e sondimeve elektrike ne rajonin detar te Vjose-Poro". Fondi i NKGJGN Fier, (bashkeautor).

VII. PROJEKTE

1. 1960 "Projekt i punimeve fushore i grupit tematik te rerave per vitin 1960". Arshiva e

fakultetit Gjeologji dhe Miniera, (bashkeautor).

2. 1962 "Projekt per punimet gjeofizike per vitin 1962
a) ekipi i elektrometrise
b) ekipi i magnetometrise
Fondi i Gjeologjise, (bashkeautor - drejtues projekti).

3. 1964 "Projekt mbi zhvillimin e punimeve tematiko-shkencore elektrometrike me metoden e sondimeve elektrike vertikale ne basenin e lumit Mat, Fan i Madh dhe Zmeje, ne vitin 1964". Fondi i fakultetit Gjeologji dhe Miniera, drejtues projekti.

4. 1965 "Projekt mbi punimet fushore eksperimentale, tematiko-shkencore gjeofizike ne rajonin e Burrelit etj, ne vitin 1965". Fondi i fakultetit Gjeologji dhe Miniera, (bashkeautor - drejtues projekti).

5. 1973 "Program per kryerjen e ciklit eksperimental te punimeve elektrometrike detare ne cektinen e Bishtit te Pall-es". Fondi i Ndermarjes Gjeologjike Tirane, (bashkeautor - drejtues projekti).

6. 1976 "Projekt per zhvillimin e punimeve eksperimentale prodhimtare te cektines detare te rajonit Durres-Bisht i Palles 1976-77". Fondi i NKGJGN Fier, drejtues projekti.

7. 1976 "Program per kryerjen e punimeve eksperimental elektrometrike per kerkimin e metaleve te cmuara ne Gjazuj, gjate vitit 1976". Fondi i Ndermarjes Gjeologjike Tirane, (bashkeautor - drejtues projekti).

8. 1977 "Projekt per ndertimin e stacionit te sondimeve elektrike vertikave detare". Fondi i Ndermarjes Gjeologjike Tirane, (bashkeautor - drejtues projekti).

9. 1978 "Projekt per vrojtimet eksperimentale elektrometrike dhe magnetometrike ne V.B. e Ballshit, ne vitin 1978". Fondi i Ndermarjes Gjeologjike Tirane, (bashkeautor - drejtues projekti).

10. 1979 "Projekt i punimeve eksperimentale metodike sheshore per kerkimin e drejteperdrejte te shtratimeve te naftes e te gazit (rilevimi gazor, luminishento-bituminologjik, radioaktivo-gjeokimik, magnetometrik, elektrometrik) ne V.B. e Ballshit". Fier. Fondi i Institutit Gjeologjik te Naftes Fier, (bashkeautor - drejtues i pjeses gjeofizike).

11. 1987 "Projekt per studimin gjeologo-gjeofizik te shelfit detar te Adriatikut per sqarimin e ndertimit gjeologo-gjeofizik dhe te nafte-gaz mbajtjes se trukturave me zhvillim ne toke e vazhdim ne det deri 5 km larg bregut". Fondi i NKGJGN Fier, (bashkeautor).

12. 1989 "Projekt shtese per temen 'mbi mundesite e rritjes se thellesise se kerkimit me metodat gjeofizike". Fondi i fakultetit Gjeologji dhe Miniera, Fondi i Ndermarjes Gjeologjike Tirane, (bashkeautor - drejtues projekti).

13. 1991 "Projekt per studimet paleomagnetike dhe gjeotermike ne Shqiperi". Programi Kombetar per Kerkim dhe Zhvillim, Gjeologjia. Fondi i Komitetit te Shkences dhe Teknologjise (drejtues projekti).

14. 1995 "Projekti per kontrollin in-situ i gjendjes se veprave hidroteknike ekzistuese dhe atyre ne ndertim, me anen e metodave gjeofizike". Programi Kombetar per Kerkim dhe Zhvillim, Gjeologjia. Sektori Shkencor i Ministrise se Burimeve Minerale dhe Energjetike. (drejtues projekti).

15. Pano N. , Frashëri A., 2000." Sensibilizimi i opinionit
shoqeror dhe publik për ndërprerjen e shkatërrimveve antropogjene në liqenin

e Prespës. Program i Granteve te Vogla te GEF (GEF/SGP)-UNDP. Bashkedrejtues Projekti.

16. Lazaridou M., Pano N., Frashëri A. etj. 2002. " Mbrojtja, administrimi dhe emergjenca i rrjetit natyror i tre tipeve te tre ekosistemeve fqinje te ndryshme: Laguna e Nartes, Lumi Vjosa, ekosistemi pyjor i ishullit tw Zvernecit dhe Parkut Kombetar te Llogarase". Programi Mjedisor "Fryma"-Fondacioni "Fryma e dashurise", Universiteti i Selanikut, Universiteti i Athinës.
17. Frashëri A., Pano N., Bushati S., 2003. Përdorimi i energjisë gjeotermale, miqësore me mjedisin". UNDP-GEF SGP, Tirana, Drejtues i Projektit.
18. Frasheri A. 2004. Atlasi i burimeve te energjise gjeotermale ne Shqiperi. Programi Kombetar per Zhvillim e Kerkim, Fakulteti i Gjeologjise dhe i Minierave.
19. Pano N., Frasheri A. etj. 2005. Hidrografia e Shqiperise". Projekt ne kuadrin e Programit Kombetar per Kerkim e Zhvillim- Pasurite Natyrore. Akademia e Shkencave, Instituti i Hidrometeorologjise.
20. Frasheri A., Pano N., Bushati S., 2005. "Promotion of the international best practices in the use of the geothermal energy in the heating and cooling of residential buildings". Project, UNDP, Tirana GEF Office. Agreement number: ALB/05/15.
21. Bushati S., Frasheri A., Nishani P., Alikaj P. 2007. Kontribute per permiresimin e fushave te zbatimeve europiane te gjeofizikes ne shqiperi, ne kontekstin e protokollit te Bolonjes. Programi Bilateral Shqiperi-Itali, 2005-2007.
22. Bushati S., Frasheri A., Nishani P., Alikaj P. 2007. "Innovative joints technologies for landslide investigation and monitoring of hazardous areas". Programi Bilateral Shqiperi-Slloveni, 2007-2008.
23. Frasheri A., Cela B., etj. 2007-2009. Platformë për shfrytëzimin integral dhe kaskadë të energjisë gjeotermale të entalpisë së ulët në kuadrin e bilancit energjetik të Shqipërisë. Programi Kombetar per Kerkim dhe Zhvillim, Uji dhe Energjia, 2007-2009.
23. Frashëri A., Çela B., Alushaj R., Pano N., Thodhorjani S., Kodhelaj N., 2008. Projekt ide për ngrohjen e godinës së Universitetit "Fan Noli" Korçë, Programi Kombëtar për Kërkim e Zhvillim, Uji dhe Energjia, 2007-2009.
24. Frashëri A., Çela B., Londo A. , Bushati S., Pano N., Shtjefni A., Thodhorjani S, Liço R., Haxhimihali Dh., Tushe F., Kodhelaj N., Baçova R., Manehasa K., Poro A., Kumaraku A., Kurti A., 2008. Qendra komplekse për shfrytëzimin modern kaskadë të ujërave gjeotermalë të entalpisë së ulët. Programi Kombëtar për Kërkim e Zhvillim, Uji dhe Energjia, 2007-2009.
25. Frashëri A., 2008. Platformë për energjinë gjeotermale në Shqipëri**.** (pjesa I) Projekti: Platformë për shfrytëzimin integral dhe kaskadë të energjisë gjeotermale të entalpisë së ulët në kuadrin e bilancit energjetik të Shqipërisë**.** Programi Kombëtar për Kërkim dhe Zhvillim "Uji dhe Energjia" (2007-2009)
26. Frashëri A., Çela B., Alushaj R., Pano N., Thodhorjani S., Kodhelaj N., 2008. ***Projekt ide për ngrohjen e godinës së Universitetit "Fan Noli" Korçë,*** Programi Kombëtar për Kërkim e Zhvillim, Uji dhe Energjia, 2007-2009.
27. Frashëri A., Çela B., Alushaj R., Kodhelaj N., Pano N., Haska H., Kumaraku A. 2009. ***Projektimi i serave gjeotermale pilot në Shqipëri***. Programi Kombëtar për

Kërkim e Zhvillim, Uji dhe Energjia, 2007-2009.

28. Frashëri A., Kodhelaj N. 2009. Platformë për energjinë gjeotermale në **S**hqipëri**.** (pjesa II)**:** Skenarët e shfrytëzimit të energjisë gjeotermale në të gjithë burimet dhe puset e ujërave termominerale në Shqipëri. Projekti: Platformë për shfrytëzimin integral dhe kaskadë të energjisë gjeotermale të entalpisë së ulët në kuadrin e bilancit energjetik të **S**hqipërisë**.** Programi Kombëtar për Kërkim dhe Zhvillim "Uji dhe Energjia" (2007-2009)

VIII. REFERATE DHE KUMTESA NE SESIONE SHKENCORE NE SHQIPERI

1. Lubonja L. Frasheri A. 1961 "Mbi perdorimin e metodave gjeofizike per kerkimin e shkriferimeve te mineraleve te rende". Sesion shkencor i Fakultetit te Inxhinerise i vitit 1961, (bashkeautor).
2. Lubonja L. Frasheri A.1962 "Aplikimi i metodave te reja gjeofizike per kerkimin e kromiteve ne rajonin e kukesit". Sesion shkencor i Fakultetit te Gjeologjise dhe Minierave, viti 1962. Fondi i NDHGJ Topografike, (bashkeautor).
3. Frasheri A., 1964 "Aplikimi i metodave gjeofizike per kerkimin e sulfideve". Sesioni i referateve te sektorit te kromit etj. Ne ISKIM 12/02/1963. Fondi i fakultetit Gjeologji dhe Miniera.
4. Frasheri A. 1964 "Influenca e shpateve te brigjeve te lumejve dhe i anizotropise se shtreses se dyte elektrike ne rezultatin e sondimeve elektrike vertikale". Sesion shkencor i Fakultetit te Gjeologjise dhe Minierave, viti 1964. Fondi i fakultetit Gjeologji dhe Miniera.
5. Frasheri A., 1966 "Mbi perdorimin e mikrorilevimit magnetik ne ndihme te rilevimit gjeologo-strukturor te shkembinjve ultrabazike". Sesion shkencor i Fakultetit te Gjeologjise dhe Minierave, viti 1966. Fondi i fakultetit Gjeologji dhe Miniera.
6. Frasheri A. 1960 "Veshtrim mbi rezultatet e perdorimit te metodave gjeofizike per kerkimin e kromiteve ne vendet e huaja". Shtypur nga kabineti teknik i ISKIM, Tirane.
7. Frasheri A., Sulstarova E. Kociu S., 1970 "Fushat fizike te Tokes jane materie qe ekziston objektivisht". Seminar teorik i Fakultetit te Gjeologjise dhe Minierave. Shtypur nga Drejtoria e botimeve te Universitetit te Tiranes, (bashkeautor).
8. Kristo T., Frasheri A. 1970 "Presionet anormale ne prerjet e trasha argjilo-ranore". Referat ne sesionin shkencor te Ndermarjes se Shpim-Kerkimit ne Lushnje. Fondi i KNG Lushnje, (bashkeautor).
9. 1973 Frasheri A., Beqiraj G., Vejsiu Y. "Interpretimi i hartave te rezultateve te vrojtimeve gjeofizike dhe gjeokimike duke perdorur analizen e siperfaqeve te prirjes". Sesion shkencor i Fakultetit te Gjeologjise dhe Minierave, dhjetor 1973. Fondi i fakultetit Gjeologji dhe Miniera, (bashkeautor).
10. Frasheri A. 1973 "Studimi statistikor i te dhenave te vrojtimeve gjeofizike me anen e makinave elektronike llogaritese". Sesion shkencor i Fakultetit te Gjeologjise dhe Minierave, dhjetor 1973. Fondi i fakultetit Gjeologji dhe Miniera.
11. Frasheri A. , Cani R., Leci V., Luga Y., Canga B. 1979 "Projektimi dhe ndertimi i stacionit te elektrometrise detare me forcat tona". Sesion shkencor i Fakultetit te Gjeologjise

dhe Minierave, me rastin e 35 vjetorit te clirimit te Atdheut, (bashkeautor).

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Increasing knowledge for a sustainable conservation and integrated management, 25 – 28 april 2012, Tirana, Albania.

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151. Frashëri A., Bushati S., 2014. PECULIARITIES OF THE ULTRABASIC ROCK MAGNETISM AND PALEOMAGNETISM DATA OF ALBANIDES OPHIOLITE. XX Congress of the Carpathian Balkan Geological Association CBGA 2014,24-26 September 2014. Tirana, Albania.

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10. RECENCA DHE OPONENCA

Jane me dhjetra recenca dhe opnenca e artikujve shkencore, te monografive, te teksteve, te disertacioneve te kandidateve te shkencave dhe te doktoreve te shkencave, te studimeve dhe te raporteve fundore, te projekteve te kerkimit shkencor dhe te projekt-diplomave, te veprimtarise kerkimore shkencore per docentet e profesoret etj. Me poshte po shkruar me kryesoret te bera ne vitet e fundit.

- M. Doracaj, S. Osmani, A. Frasheri 1993 Recence per "Projekti Ligjor i Hidrokarbureve (Kerkim - Prodhimi)". Ministria e Industrise, Burimeve Minerare dhe Energjitike.

- M. Doracaj, S. Osmani, A. Frasheri 1993 Recence per Projekt kontrate "Draft Model PSA 1/93" per mardheniet me firmat e huaja per industrine e naftes. Ministria e Industrise, Burimeve Minerare dhe Energjetike.
- Sh. Aliaj, E. Sulstarova, S. Koçiu, B. Muço, 2011. “Sizmiciteti, sizmotektonika dhe vlerësimi probabilitar i rrezikut sizmik në Shqipëri”. Monografi, Botim i Akademisë së Shkencave e Shqipërisë, Tiranë.

X. ARTIKUJ PROBLEMORE DHE SHKENCORO-POPULLORE NE SHTYP DHE PERIODIKUN JO SHKENCOR

1. 1968 "Mbi specializimin masiv ne gjeologji". Zeri i Popullit Nr 261, 31 Tetor 1968, (bashkeautor).
2. 1970 "Studimet krahinore gjeologo-gjeofizike jane detyre e domosdoshme e kohes". Zeri i Popullit Nr 242, 10 Tetor 1970, (bashkeautor).
3. 1970 "Gjurmet e te pa dukshmit dhe gjeofizika". Shkenca dhe Jeta Nr. 4 1970, (bashkeautor).
4. 1974 "Gjeofizika tek ne eshte e re, ajo po zhvillohet me vrull". Zeri i Popullit Nr 9 (7927), 11 Janar 1974, (bashkeautor).
5.. 1974 "Ne gjeologji mund te perdoren me gjere metodat matematikore". Zeri i Popullit Nr 10 (7988), 23 Mars 1974, (bashkeautor).
6.. 1982 "Matematika llogaritese ne sherbim te metodave gjeofizike te kerkimit". Zeri i Popullit 10 Korrik 1982, (bashkeautor).
7. 1985 "Katedra jone eshte nje qender e rendesishme e informacionit shkencor". Zeri i Popullit Nr 279 (11039), 10 Dhjetor 1985, (bashkeautor).
8. 1992 "Ekonomia e tregut dhe heshtja per kerkimet gjeologjike". Alternativa SD, 21 Prill 1992.
9. 1992 "Nentoka eshte gati te zgjohet". Alternativa SD, 28 Prill 1992.
10. 2000..”Gjeoshkencat: Na llogarisni edhe ne”. Republika, 7 Dhjetor, 2000
11. “Gradaçelat shqipatare nuk kane studime gjeologo-gjeofizike” Koha e Jone, 17 Prill, 2001
12. 2001. ”Shqiperia nuk duhet ta humbase liqenin Prespa e Vogel”. Koha Jone, 7 Maj, 2001.
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VLERESIME HONORIFIKE

Urdhera dhe medalje

Dekorata „Nderi i Akademisë", 21 prill 2015. Akademia e Shkencave e Shqipërisë, Kryesia.

Urdhëri „Mjeshtër i Madh", nga Presidenti i Republikës së Shqipërisë:, Dekret Nr. 7624, date 10.07.2012.

„Nderi Frashërit", nga Komuna Frashër, Vendim Nr. 17, datë 20 prill 2011.

Medalja „Mirenjohje" me rastin e 55 vjetorit të Institutit të Lartë Politeknik, 2006. Rektorati UPT

"Medal of Honor 2000 Millenium", nga American Biographical Institute , 5.6.4. 2000

Urdheri "Naim Frashëri" i klasës së III- të, nga Kuvendi Popullor, Tiranë, 1977

„Medalja e Punës", nga Kuvendi Popullor, Dekret 2190, datev26.12.1955, Patos 1955

Anëtar Nderi

Shoqata Atdhetare Kulturore Mbarëkombëtare "Vëllezërit Frahëri", 20 tetor 2014.

Honorary Member of Balkan Geophysical Society, 3rd Congress of Balkan Geophysical Society, Sofia, 24-28 June 2002.

Honorary Member of European Association of Geoscientists and Engineers. Nomination in the Conference and Exhibition, Madrid 2005.

New York Academy of Sciences, Active Member, 1999

Man of the Year 1996, International Biographical Centre, Cambridge, England
Man of the Year 1998, International Biographical Centre, Cambridge, England
Iternational Man of the Year 1998, International Biographical Centre, Cambridge, England
TOP 100 COMMUNICATORS 2006, International Biographical Centre, Cambridge, England
Man of Year 2010 abi
TOP 100 PROFESSIONALS 2012, International Biographical Centre, Cambridge, England

Biografi.

5.1. Kalendar Enciklopedik I.,Botim Venera Shkp., Tirane 1998.
5.2. Fjalori Enciklopedik Shqiptar. Vell. 1. Akademia e Shkencave e Shqiperise, Tirane, 2009.
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Internet site Yahoo.com.; and Google: www.”Alfred Frasheri”

Tirane, 18 mars, 2016
Prof. Dr. Alfred FRASHERI

CURRICULUM VITAE

Surname **FRASHERI**

First Name **Alfred**

Day of the birth: 20 April 1935

Nationality Albanian

Profession Geophysicists, Doctor of Sciences, Professor on Geophysics.

Actual position

1) Part time Professor in the Section of the Geophysics, Faculty of Geology and Mining, Polytechnic University of Tirana (1998- up to present). Responsible for university courses:
   "Physics of Earth" 5th year of Geophysical Branch
   "Physics of Earth" in the framework of the Course "Geodynamics", 4th year of Geological Branch.
   "Geothermy" 5th year of Geophysical Branch.
2) Retired from 1.12.1998.
3) Member of the "ALBANIAN GEOPHYSICAL SOCIETY", Past Chairman.
4) Member of the Executive Committee of the "ALBANIAN ASSOCIATION OF GEOSCIENTISTS AND ENGINEERS", past Chairman.
5) Honorary Member of European Association of Geoscientists and Engineers (EAGE).
6) Honorary Member of Balkan Geophysical Society (BGS)

Former appointments or occupations:

1. Director of the Department of Earth Sciences (1994 - 1996).
2. Director of Geological- Geophysical Department (1993-1994),
3. Chairman of Chair of Geophysics (1992-1993),
4. Lecturer (part time 1961-1962, full time 1962-1981), Ass. Prof.(1981-1989), Full Prof. (1998-1998), Faculty of Geology and Mining, Chair of Geophysics.
5. Project Leader, Geophysical Team, Tirana Geological Enterprise (1961-1962).
6. Student, Tirana University, Faculty of Geology and Mining, 1957-1961.
7. Well-logging Technician, Well-logging Team, State Drilling Enterprise, Patos, Albania (1953-1957).
8. Project leader of GEOTEC Shpk Tirana, Albania (1995-1997).

5\. Vice President and Director of Canadian-Albanian Joint Ventures "Karma Albanian Mining" Ltd and "Skenderbeg Mining Co. Ltd. (1996-1997 during Karma and Skenderbeg Co. in Albania).

6\. External (from Albania) Senior Geophysical Consultant of QUANTEC IP Inc., Toronto, Canada. (1992-2001).

7\. Part time responsible for the Summer Postgraduate "Quantec Geosciences Technological Training School", Timmins, Canada (2000, 2001).

Internet site Yahoo.com. and Google: www."Alfred Frasheri"

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DIRECTION OF SCIENTIFIC ACTIVITY

1. Geothermal studies (Since 1989 up to present)
2. Engineering geophysics (Since 1982 up to present)
3. Application of mathematical methods in data processing and interpretation of geophysical information with the aid of computers, compilation of algorithms and programs for these purpose (Since 1972)
3. Experimentation and application of new geophysical methods, like that of Induced Polarization (1962), and that of magnetic micro-survey (1967) in the exploration of copper and chrome ores.
4. Extension of the application field of the geophysical methods in the search for chrome, copper, asbestos, bauxite, placer of heavy, rare and precious minerals, in the study of geological engineering and hydrogeology; the application of Self-potential method in direct exploration of oil and gas reservoirs, application of marine geoelectrical methods (Since 1961)
5 Regional geophysical studies (Since 1961)

MEMBER OF DIFFERENT FORUMS

2006.	Expert of BALWOIS Program Expert (Water Observation and Information System for Balkan Countries) (www.Balwois).
2004.	Expert of European DataBank Sustainable Development (EUDB)
1999- 2001	Member of Executive Committee of Albanian Association of Geoscientists and Engineers
1989-1999	Chairman of Albanian Association of Geoscientists and Engineers
1992-2000	Chairman of Albanian Geophysical Society
1993	Honorary Member of the Balkan Geophysical Society.
1991	Honorary Member of the European Association of Geoscientists and Engineers (E.A.G.E.).
1994	Member of Society of Exploration Geophysicists (S.E.G.) U.S.A., from 2002- Global member
1995	Member of International Geothermal Association (IGA)
1993 - 1997	Commission for Scientific Training at the Council of Ministers of Republic of Albania.
1992-1996	Member of the Scientific Council of the Rectorate of Polytechnic University of Tirana.
1989- 1996	Scientific Council of Faculty of Geology and Mining, Polytechnic University of Tirana.
1992-1995	Member of the Board of the Albanian TEMPUS Office.
1991-1992	Member of the Committee of Science and Technology, Albania.
1990-1991	Member of Scientific Council of the Rectorate of University of Tirana.

1989-1991	Member of High Commission of Postgraduate Qualification near the Council of Ministers of Republic of Albania (for approvals of scientific degrees and titles Ph.D., M.Sc., docent, professor).
1987-1991	Member of the Jury of Ph.D. Thesis Maintenance for Geology and Geophysics in the Faculty of Geology and Mining, University of Tirana, Albania.
1975-1987	Scientific Council of Geological Institute of Oil and Gas in Fier, Albania.
1987-1991-	Scientific Council, Petroleum Branch, Ministry of Industry and Mining.
1973-1983	Member of Geophysical Section near the Academy of Sciences of Republic of Albania.

CURRICULUM SCIENTIFICO-ACADEMICO

Title of Studies: Dip. Eng. Geologist in 1961, Faculty of Engineering, University of Tirana.

Title of Thesis:

a) **3rd cycle doctor** (M.Sc) in 1974 with the thesis "Physical properties of chrome-spinele and ultrabasic rocks of Tropoja massif in relation with expected geophysical anomalies".

b) **Doc. of Science** (PhD) in 1987 with the thesis "Investigation of electrical field scattering through heterogeneous geological media". Polytechnic University of Tirana, (in Albanian).

Post-University Courses: "Signal Processing" in 1984 in University of Pau, France.

Academic Titles:

- Lecturer 2 in 1961
- Lecturer 1 in 1968
- Docent in 1981
- Full Professor in 1989

Studies visits (2-4 weeks):

1992 University of Study of Bari, Italy
University of Study of Milan, Italy
Institute of Geology and Mineral Exploration of Athens, Greece.
Geophysical Institute of Acad. Of Science, Prague.
ELGI, Budapest, Hungary
University of Budapest, Hungary

1993 Geophysical Institute of Acad. Of Science, Prague

1994 University of Leeds, UK
University of Thessaloniki
Geophysical Institute of Acad. Of Science, Prague

1995 University of Thessaloniki
University of Study of Milan, Italy
Geophysical Institute of Acad. Of Sciences, Prague

1996 Imperial College, Royal School of Mines, London, UK
Institute of Geology and Mineral exploration of Athens, Greece.
University of Ulster at Coleraine, Environmental School, UK.
University of Thessaloniki.

1997 PDAC 1997 Annual International Convention & Trade Show,

March 9-12,1997 , Toronto, Canada and Quantec Inc., March 12-25 1995, Downwater, Canada.

1998. Invited lecturer in the Summer School: Geothermal Days, Oregon Institute of Technology, Klamath Falls.

1999. Invited lecturer in the Summer School: Geothermal days, Ohrid, Macedonia.

2000 Invited lecturer in the Post-graduate Summer School of QUANTECGEOSCIENCE Inc. Toronto, Canada, Korrik-Gusht 2000.

a) Preparation of Teaching Plan of the School
b) Preparation of the Program of "Theoretical basis of the applied geophysics"
c) Lectures of the course "Theoretical basis of the applied geophysics"

2004. Invited lecturer in the Summer School: Geothermal days, Zakopane, Poland.

2006. Invited lecturer in the Summer School: International Summer School of Geothermal Exploration-prospecting–reservoir engineering- monitoring, 28 may - 11 June 2006 Izmir/Turkey

LICENSES, *P.E.* (Licensed Professional Engineer) in Albania
Licensed Commercial Pilot.

Languages: Albanian (native language)
French(well)
Russian(fluently)
English (well)
Italian (sufficiently)

<u>BOOKS</u>

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3. Frasheri A., Papa K., Lico R., Mucko S. 1970. Well logging. University of Tirana Publishing House (in Albanian).
4. Frasheri A. 1970, re-edition 1973, 1984. Some measuring instruments for direct current Electrical Prospecting. University of Tirana Publishing House (in Albanian).
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10. Frasheri A. 1990 Mining Geophysics. University of Tirana Publishing House (in Albanian).
11. Frasheri A. 2005. Engineering and Environmental Geophysics. Published by Faculty of Geology and Mining, Polytechnic University of Tirana.

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22. Frasheri A. 1983. Some results obtained through the application of geophysics in hydrological research. Bulletin of Geophysical Sciences (Tirana) No. 1, 47 - 62, (In Albanian, summary in French and English).
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26. Frasheri A. 1985. Problems of interpretation of electrical sounding results in regions with complicated geophysical peculiarities. Bulletin of Oil and Gas No. 3, 39 - 63, Fier, (in Albanian, summary in English).
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